MODELS OF REGULATING WATER IN TRANSBOUNDARY RIVER BASINS: A NEXUS OF HYDROPOLITICS AND ELECTRICITY TRADE

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ABSTRACT

MODELS OF REGULATING WATER IN TRANSBOUNDARY RIVER BASINS: A NEXUS OF HYDROPOLITICS AND ELECTRICITY TRADE

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The central topic of this study is the nexus between water and hydroelectricity. The main issue discussed here is how economic activity influences and is being influenced by water management, hydroelectricity production and electricity trade in key transboundary river basins. The unit of analysis is the state, the limits of which are defined by modern political boundaries; and the geographically demarcated river basins that involve the selected cases are subject to evaluation in broader context. In terms of energy trade relations, the primary focus is on the dyadic interconnections between the riparians, although basin-wide regional electricity trade relations are discussed in a complementary manner.

The research question this study aims to address is how and to what degree state-level water management policies affect and are being affected by the dyad-level hydropower trade. The initial hypothesis tested is that there is a dialectical and inverse relationship between the level of trade (or sharing) of hydroelectricity between political units in a transboundary river basin and the number and severity of water-induced and mostly economy based dyadic issue areas between riparians. The findings of the study confirm the hypothesis.

This thesis assumes that there are some factors that may augment or impede the severity and the number issue areas between the riparians in key river basins, and also, that may increase or decrease the level of hydropower traded across boundaries. These are the geographical features of the cases; institutional and legal frameworks that deal with water, energy and environment issues in specific river basins; the varying nature of backgrounds based on environmental histories; and the structure and size of the economic activity within a river basin. The chapters of this study are designed in accordance, with the focus being on the economic aspects of dams, which play a decisive role in water management, economic development, and hydropower production.

Keywords: water-energy nexus, water management, dams and hydropower, interconnections, energy trade

ÖZ

SU VE ENERJİ İLİŞKİSİ YÖNETİM MODELLERİ: HİDROPOLİTİK VE ELEKTRİK TİCARETİ ÜZERİNE KARŞILAŞTIRMALI BİR ANALİZ

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Bu çalışmanın ana konusu su ve hidroelektrik enerji arasındaki ilişkidir. Burada tartışılan esas mesele, önemli uluslararası nehir havzalarında iktisadi faaliyetin su yönetimi, hidroelektrik enerji üretimi ve elektrik ticaretini nasıl etkilediği ve bunlardan nasıl etkilendiği meselesidir. Çalışmada analiz birimi olarak sınırları modern siyasi hudutlarla belirlenen devletler ele alınmıştır. Ancak daha geniş manada sınırları coğrafya tarafından belirlenen nehir havzaları da örnek ülkeler ile ilişkileri bağlamında bu çalışma kapsamında değerlendirilmektedir. Enerji ticareti bağlamında ise temel odak noktası kıyıdaş ülkeler arasındaki ikili elektrik ticareti olmakla birlikte, bu tartışmayı tamamlayıcı olarak havza genelinde gerçekleşen bölgesel elektrik ticareti de gündeme getirilmektedir.

Çalışmanın cevaplamaya çalıştığı araştırma sorusu, ülkeler arası su yönetimi politikaları ile ülkeler arası ikili elektrik ticareti arasında nasıl ve ne yönde bir bağlantı olduğu sorusudur. Test edilen başlangıç hipotezi, belli bir sınır aşan nehir havzası içinde yer alan siyasi birimler arasındaki hidroelektrik enerji ticareti veya paylaşımının seviyesi ile kıyıdaşlar arasında su kaynaklı ve ekonomik temelli ikili sorun alanlarının sayısı ve şiddeti arasında iki yönlü ve ters bir ilişki olduğu yönündeki hipotezdir. Çalışmanın bulguları genel olarak bu hipotezi doğrulamaktadır.

Bu çalışmanın temel varsayımı, önemli nehir havzaları dâhilinde, kıyıdaş ülkeler arasındaki siyasi veya iktisadi meselelerin şiddetini ve sayısını artıran veya azaltan, aynı zamanda da komşu iki ülke arasında gerçekleşen hidroelektrik enerji ticaretinin seviyesi üzerinde belirleyici olan bazı unsurlar olduğudur. Bunlar arasında coğrafya, kurumsal ve yasal çerçeve, siyasi tarih gibi unsurlar önemli yer tutmakla birlikte, nehir havzaları genelindeki iktisadi faaliyetin yapısı ve büyüklüğü de kritik öneme sahiptir. Bu varsayımlar çerçevesinde çalışmada temel alınan odak noktası, su yönetimi, iktisadi kalkınma, elektrik üretimi ve su siyaseti açısından belirleyici rol oynayan ve bürokrasi ve siyaset açısından önemli ve geniş kullanımlı araçlar olan sulama ve elektrik üretimi amaçlı barajların ekonomik açıdan incelenmesidir.

Anahtar kelimeler: su-enerji ilişkisi, su yönetimi, barajlar ve hidroelektrik, elektrik ticareti

To my son Barış and to my family

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My family has always been very supportive for whatever I read or study. I owe them apologies for devoting most of my time for reading, travelling, and writing during the completion of this study. I found chances to go to Southeast Asia, Central Asia, and America, with the support of some institutions. In that respect, I would like to thank Universitaet Tübingen and Volkswagenstiftung for inviting me to Central Asia to present my work on Soviet Central Asian environmental history, Eurasian Research Institute for financing a short field research on Central Asian water and energy issues and for accepting me join a summer school there, the International Monetary Fund and the World Bank for supporting me travel for the annual meetings as a member of the Central Bank of the Republic of Turkey.

My eight years at the Central Bank of the Republic of Turkey contributed to my knowledge on and my analytical understanding of macroeconomic issues, which were of great help during the completion of this study. I would like to thank all my colleagues for their understanding during the times I left for the courses and seminars I attended. Needless to say, all the views expressed in this thesis belong solely to me. Likewise, I bear the responsibility of all the mistakes and errors that I may have omitted in this text.

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LIST OF ABBREVIATIONS

AD	anno Domini
ADB	Asian Development Bank
ASEAN	Association of Southeast Asian Nations
BC	before Christ
BWO	Basin Water Association
CAPS	Central Asian Power System
CEC	Commission for Environmental Cooperation
EAPP	Eastern Africa Power Pool
ECAFE	UN Economic Commission for Asia and the Far East
ENSAP	Eastern Nile Subsidiary Action Program
EU	European Union
FAO	Food and Agriculture Organization of the UN
FRIEND	Flow Regime from International Experimental and Network Data Project
GDP	gross domestic product
GMS	Greater Mekong Subregion (Programme of ADB)
GOELRO	*Gosudaarstvennaya elektrifikatsiya Rossii* (State Electrification of Russia)
GWh	gigawatt-hours
GWP	Global Water Partnership
HPP	hydroelectric power plant
Hz	Herz
IAD	institutional analysis and development
IBWC	International Boundary and Water Commission
ICWC	Interstate Commission for Water Coordination
IFAS	International Fund for Saving the Aral Sea
IJC	International Joint Commission
IMPACT	international model for policy analysis of agricultural commodities and trade
IPE	International Political Economy
IR	International Relations

IWRM	integrated water resources management
ktoe	kilotons of oil equivalent
kV	kilovolt
kWh	kilowatt-hours
M-POWER	Mekong Programme on Water, Environment and Resilience
MERCOSUR	*Mercado Común del Sur* (Southern Common Market)
MRC	Mekong River Commission
MWh	megawatt-hours
Mtoe	million tons of oil equivalent
NAFTA	North American Free Trade Agreement
NATO	North Atlantic Treaty Organization
NBI	Nile Basin Initiative
NELSAP	Nile Equatorial Lakes Subsidiary Action Program
NGO	non-governmental organization
OECD	Organization for Economic Co-operation and Development
RBM	river basin management
SIWI	Stockholm International Water Institute
SSR	Soviet Socialist Republic
TPP	thermal power plant
TWh	terawatt-hours
UK	United Kingdom
UN	United Nations
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations International Children's Emergency Fund
US	United States
USAID	US Agency for International Development
USBR	United States Bureau of Reclamation
WECC	Western Electricity Coordinating Council
WHO	World Health Organization
WMO	World Meteorological Organization

CHAPTER I

INTRODUCTION

> "We must conquer the desert." Why? "So there will be homes and farms for more people." Why? "So there will be more wealth to go around." What is the wealth for? "Whatever people like, or come to decide—it's not a question we can address."
>
> Donald Worster, 1985[1]

Irrigation, river basin management, and hydroelectricity have long been significant catalysts of social wealth and economic development. The second half of the nineteenth century was a breaking point in that respect as investments in large hydraulic works gained pace globally. The Americans began developing the great river basins of the arid West, the British controlled the Nile River basin just after the occupation of Egypt and the Sudan, and the Russians concentrated on irrigation in Central Asia since the early days of their presence in the Aral Sea basin. The common ground was a focus on irrigated agriculture, especially on the cultivation of high-yield crops. The main irrigation zones were arid, where irrigation needs sophisticated technology and expertise, along with high volumes of water. Irrigation ventures on arid lands through sophisticated water development schemes since to have contributed to the wealth of these empires and their remnants. However, at the same time, these

[1] Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Oxford University Press, 1985).

processes have had considerable and irreversible impacts on the social and natural environment.

The second half of the 2010s stood witness to significant historical developments regarding water policies of the major powers and the major developing countries. The US has initiated a process of undamming the nation,[2] while others concentrated on extending the networks of dams and reservoirs. The Ethiopian government kicked off the Great Renaissance Dam in 2011, a real milestone for the Nile river basin. Turkey initiated numerous ambitious projects in the underexploited north-eastern part of the country with the increasing involvement of private sector. A more-than-half-century giant dream, the Rogun Dam project, officially kicked off in late 2016; and the Kyrgyz authorities began test drills for yet another giant project, the Kambarata, in 2013. China completed the controversial Three Gorges Dam in 2012, and now, it possesses the most extensive hydropower generating capacity in the world in a single dam. Furthermore, it has three out of five tallest dams on the planet by 2013. Politics and economic decisions are involved in all major development projects.

1.1. Subject matter of the study

The primary concern of this study is water. Not all the water on the earth surface is dealt with here. More than 97 percent of the total water on earth is salty, not suitable for direct human use.[3] The remaining three percent is classified as freshwater, more than two-thirds of which is stored in glaciers and permanent snow, and the largest part of the remaining one-third (30 percent) is underground. Less than one percent (only 0.34 percent) of the total freshwater on earth surface is in the form of lakes and swamps (0.29 percent) and in the atmosphere (0.04 percent). The rivers, the

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[2] World Commission on Dams, *Dams and Development: A New Framework for Decision-Making* (London and Sterling: Earthscan, 2000), pp.10-11.

[3] Gregory Morris & Jiahua Fan, *Reservoir Sedimentation Handbook: Design and Management of Dams: Reservoirs, and Watersheds for Sustainable Use* (New York: McGraw-Hill, 1997), p.2.1.

most common, and sometimes only, source of available freshwater for humans, make up only 0.01 percent of this freshwater. This corresponds to a volume of 2.1 thousand cubic kilometers in total.[4] The focus of this study is on this relatively small amount of freshwater.

While this relatively small amount of water is directly exploitable for humans, like all natural resources on earth, water is not uniformly distributed and usually flows unregulated. Regulating the flow of rivers, storing water, diverting it towards agricultural and industrial zones, cities, and towns have been old practices for human civilizations since antiquity. Today, high dams and reservoirs regulate nearly one-third of the available surface freshwater flows on earth surface (about 3,500 cubic kilometers per year).[5] In other words, this study is interested in fresh surface water in the form of rivers and stored in reservoirs, which corresponds to one-ten-thousandth of the total freshwater available on the planet.

In that respect, the primary subject matter of this study is the relationship between the economic activity based on regulated freshwater in key transboundary river basins and the trade of hydroelectricity, which is particularly generated by large dams,[6] between the riparians.

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[4] Gregory Morris & Jiahua Fan, *Reservoir Sedimentation Handbook: Design and Management of Dams: Reservoirs, and Watersheds for Sustainable Use* (New York: McGraw-Hill, 1997), p.2.1.

[5] L. Berga et al., "Dams and reservoirs, societies and environment in the 21st century," in *International Symposium on Dams in the Societies of the 21st Century, ICOLD-SPANCOLD*., 2006, p.xvii.

[6] The International Commission on Large Dams classifies dams higher than 15 meters as large dams. See: International Commission on Large Dams, "General Synthesis," *CIGB/ICOLD*, 2011, available at: www.icold-cigb.org (accessed 20 December 2016).

1.2. Scope and methodology

The level of analysis of this study is the state. The cases investigated are the United States (US), China, Kyrgyzstan, and Egypt. The major transboundary rivers[7] are included into analysis with regards to their weight and importance in the economic activity of these states and with regards to the impact on the relationship between hydropolitics and the basin-level bilateral electricity trade. More than ten major river basins are scrutinized in that respect, including the Amur, the Aral Sea, the Colorado, the Columbia, the Ganges-Brahmaputra-Meghna, the Great Lakes, the Irrawaddy, the Mekong, the Nelson-Saskatchewan, the Nile, the Rio Grande in North America, the Salween, the Tumen, and the Yalu river basins.

The cases are selected based on a logic that allows a comparative approach. Among the four cases selected for scrutiny in this study are two leading water users, the US and China, which are, at the same time, among the top hydroelectricity producers and top electricity consuming nations globally. While the former two cases are regional and global political powers with considerable sizes of economies, the remaining two cases are developing economies with relatively smaller water and electricity use, selected from among the regions with traditional hydropolitical disputes.

The comparative approach in this study is closer to the principles of the most different systems design.[8] In this methodology, the different features (independent

[7] The "transboundary rivers" in the context of this study are the rivers that cross or establish the political boundaries between the riparian states within the geographical limits of major river basins.

[8] Adam Przeworski & Henry Teune, *The Logic of Caomparative Social Inquiry* (Malabar: Krieger Publishing, 1970).

variables) of a number of systems with same or similar outputs are studied comparatively. The expectation is that the outputs do not vary significantly, and, if they do, systemic variables are taken into consideration for explaining possible variances.[9]

To provide convincing answers to the research questions and topics studied here, the cases are selected as to possession of varying geographical features, as well as from different social, environmental, and historical backgrounds. The levels of integration in terms of electricity trade in the cases are different from each other, and the demand structure, the ability, the political will, and the potential of using renewable fuels as the source of electricity generation, as well as the demand for water for agricultural, industrial and other economic purposes, vary significantly among the cases. The similar output is an obvious relationship between the economic activity and the main water management issues in key river basins.

With regards to electricity trade and interconnections, some principal regional trade schemes are investigated in this study, such as the Western Electricity Coordinating Council (WECC) of North America, the Greater Mekong Subregion (GMS) interconnection in Southeast Asia, the Asian Super Grid Project in East Asia, the Central Asian Power System (CAPS) in Central Asia, and the Eastern African Power Pool (EAPP) in the Northeast Africa.

1.3. Placing the study in the literature

The presence of various stakeholders engaged in water-related issues, from non-profit international organizations to multinational companies and from academia to politicians and decision-making bureaucratic mechanisms resulted in a substantial

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[9] Carsten Anckar, "On the Applicability of the Most Similar Systems Design and the Most Different Systems Design in Comparative Research," *International Journal of Social Research Methodology*, vol. 11, no. 5, 2008, p.391.

number of studies in the literature, as Du Plessis observed, on multiple levels.[10] While volumes of reports and projects steered or sponsored by international organizations have been populating the libraries of water managers with an increasing pace, theoretical work is proliferating at a similar speed. As acknowledged by the members of various disciplines, water-related issues usually require a multidisciplinary approach.[11] This multidisciplinary characteristic of the subject contributes to the expansion of the volume of the relevant literature, on one hand, and it complicates theorization endeavors on the other.

This study is a contribution to the studies on transboundary water issues from an International Relations (IR) perspective. The central framework of analysis is the nexus of hydropolitical relations between the riparians and transboundary electricity trade. Among their difeerences as listed above, there are common features of the cases investigated in this study. All the cases analyzed in this study share key and globally important transboundary river basins with their neighbors, and the wieght of water in the histories of economic development of these cases are crucial. This study aims to investigate the main water management policies in these key transboundary river basins and the particular role played here by hydroelectricity trade between the riparian states.

1.4. Research questions and structure

This study tries to figure out the role of renewable energy, in the form of hydropower, in the hydropolitical relations between the riparians in selected river basins. The research question this study aims to address is how and to what degree state-

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[10] Anton Du Plessis, "Charting the Course of the Water Discourse Through the Fog of International Relations Theory," in H. Solomon & A. Turton, eds. *Water Wars : Enduring Myth or Impending Reality*, 2000.

[11] Jeanne Féaux de la Croix, "Opening Remarks," in *The Social History and Anthropogenic Landscape of the Syr Darya River Basin: Exploring an Environmental Archive*., 2016; Thomas Homer-Dixon, "On the Threshold: Environmental Changes as Causes of Acute Conflict," *International Security*, vol. 16, no. 2, 1991, p.84.

level water management policies affect and are being affected by the dyad-level hydro-power trade.

The initial hypothesis tested is that there is a dialectical and inverse relationship between the level of trade of hydroelectricity between political units in a trans-boundary river basin and the number and severity of water-induced and economy based dyadic issue areas between riparians. This study assumes that there are some factors that tend to increase the severity and the number of water-based political and economic issue areas between the riparians in the key transboundary river basins among the world. Among these are the geographical features of the cases (the states, or, more specifically, the Basin Country Units),[12] institutional and legal frameworks that deal with water, energy and environment issues in specific river basins, the historical development of relations between the riparians based on water economy, and the the level of economic dependency on freshwater resources. All these factors are evaluated in this study with regards to their connection to basin-level electricity trade.

Before going into the scrutiny of cases, the first two chapters of this thesis review and analyze the relevant theoretical approaches to water and hydroelectricity. The first chapter positions the approach of the study within the literature of the IR theory. The chapter begins with a discussion on the dominant conflict and cooperation literature and then analyzes the main features of water and energy nexus and water management discussions in the literature. The chapter also summarizes the critical approaches to these discussions. The second chapter concentrates on economic aspect of hydroelectricity and begins with analyzing the institutional aspect, as well as the demand and supply structures of water and tries to review how this demand and supply are balanced or managed. The discussion in this chapter goes on with

[12] The Transboundary Waters Assessment Programme defines a Basin Country Unit as “the portion of a country within a particular river basin.” See: UNEP/GEF, "TWAP RB Basin Factsheet: Data Sources," *Transboundary Waters Assessment Programme*, 2014, available at: http://twap-rivers.org/assets/Factsheet_template_with_references.pdf (accessed 24 February 2018).

the economic aspects of dams, and water diversions, as well as their uses and possible impacts on social world and environment. The chapter also discusses the economy of energy interconnections.

The third, fourth, fifth, and sixth chapters deal with the cases selected for scrutiny in this study. The chapters have similar structures, beginning with an introduction and a geographical analysis. Then, the chapters deal with the water development projects in selected river basins and investigate the major water issues. Also, the supply and demand of renewable energy, and the role of electricity interconnections are analyzed. The final and concluding chapter is a general assessment of the water and energy nexus based on the cases analyzed in the text. It discusses the main findings of the study and the validity of the initial hypothesis.

CHAPTER II

THEORETICAL APPROACHES

> Remember the last time two nations went to war over water? Probably not, since it was 4,500 years ago. But today, as demands for water hit the limits of a finite supply, conflicts are spreading within nations.
>
> Sandra L. Postel and Aaron Wolf, 2001[13]

> Modern man does not experience himself as a part of nature but as an outside force destined to dominate and conquer it.
>
> E. F. Schumacher, 1975[14]

2.1. Introduction

Wars or interstate conflicts have long been among the leading subjects on the agenda of the International Relations (IR) scholars, and other issues remained secondary to security concerns. Towards the end of the Cold War, the focus on high politics began to change, and environmental studies flourished, with alternatives to traditional high-political theoretical and political outlooks.[15] A considerable part of

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[13] Sandra Postel & Aaron Wolf, "Dehydrating Conflict," *Foreign Policy*, vol. 126, 2001.

[14] E. Schumacher, *Small Is Beautiful: Economics As If People Mattered* (New York: Perennial Library, 1973).

[15] Anton Du Plessis, "Charting the Course of the Water Discourse Through the Fog of International Relations Theory," in H. Solomon & A. Turton, eds. *Water Wars : Enduring Myth or Impending Reality*, 2000, p.9.

this newly emerging literature belongs to transboundary water systems.[16] Although in the post-Cold War era critical approaches to political environmental studies increased in number and scope, traditional interpretations based on problem-solving perspectives as conceptualized very famously by Robert Cox since to have preserved their preeminence in the literature,[17] and, in parallel, the number and scope of critical perspectives on water issues remained quite limited within the IR studies.[18]

As an extension of the dominance of realism in theoretical IR studies, water-related research inspired by mainstream neorealism insists on accentuating state-centric perspectives, while neoliberalism-inspired water research concentrates on institutions and regime development. In parallel, the literature based on "water and conflict" is a reflection of the former relationship, while the literature on "water-induced cooperation" and "water governance" may be seen as the reflections of the latter.[19] Du Plessis studies the theory of water discourse on three levels and argues that at the macro-level, neither academicians nor policy-makers have a particular theoretical position regarding water politics, and most of the literature is an extension of mainstream rationalist and positivist theories of IR. At the meso-level, the theoretical aspect of the water discourse is somewhat more developed, yet theorizing remains within the boundaries of realism and liberalism. At the micro-level, the

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[16] Kathryn Furlong, "Hidden Theories, Troubled Waters: International Relations, the 'Territorial Trap', and the Southern African Development Community's Transboundary Waters," *Political Geography*, vol. 25, no. 4, 2006.

[17] Robert Cox, "Social Forces, States and World Orders: Beyond International Relations Theory," *Millennium - Journal of International Studies*, vol. 10, no. 2, 1981.

[18] Jeroen Warner & Mark Zeitoun, "International Relations Theory and Water Do Mix: A Response to Furlong's Troubled Waters, Hydro-Hegemony and International Water Relations," *Political Geography*, vol. 27, 2008, p.803; Kathryn Furlong, "Hidden Theories, Troubled Waters: International Relations, the 'Territorial Trap', and the Southern African Development Community's Transboundary Waters," *Political Geography*, vol. 25, no. 4, 2006, p.439.

[19] Anton Du Plessis, "Charting the Course of the Water Discourse Through the Fog of International Relations Theory," in H. Solomon & A. Turton, eds. *Water Wars : Enduring Myth or Impending Reality*, 2000, pp.21-22.

literature scrutinizes causality, focusing on “resource scarcity as an independent variable and (sustainable) development, (in)security and (violent) conflict as dependent variables.”[20] Furlong recapitulates the mainstream IR perspectives in water discourse as follows: Realism and hegemonic stability theory, as well as normative theories, are employed to scrutinize the “watercourse agreements;” game theory is used to analyze conflict and cooperation potential; liberal interdependence approach is used to understand the “transboundary water ‘regimes.’”[21] A selected part of this literature is reviewed in this chapter.

2.2. Water and conflict

Transboundary rivers are essential subjects of international politics as nation-states tend to see the rivers within their political boundaries as objects of sovereignty. In addition, water, as a resource, is a means for development, the allocation and management of which are strictly related to economic growth.[22] In the literature, there are severe attempts of theorizing the relationship between shared rivers and interstate conflict. Most of this literature is closely associated with realism, or more specifically, to the issue-linkage based Malthusian and neo-Malthusian approaches[23] to inter-state conflict.[24] These approaches consider the dyadic relationship in a shared river basin as competition for scarce resources.

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[20] Anton Du Plessis, "Charting the Course of the Water Discourse Through the Fog of International Relations Theory," in H. Solomon & A. Turton, eds. *Water Wars : Enduring Myth or Impending Reality*, 2000, pp.27-28.

[21] Kathryn Furlong, "Hidden Theories, Troubled Waters: International Relations, the ‘Territorial Trap’, and the Southern African Development Community's Transboundary Waters," *Political Geography*, vol. 25, no. 4, 2006, p.453.

[22] Selina Ho, "Introduction to ‘Transboundary River Cooperation: Actors, Strategies and Impact’," *Water International*, vol. 42, no. 2, 2017, p.98.

[23] See, for a discussion on Malthusian and neo-Malthusian theories: Koula Mellos, "Neo-Malthusian Theory," in *Perspectives on Ecology*, 1988, pp.15-16.

[24] Kathryn Furlong, Nils Gleditsch & Håvard Hegre, "Geographic Opportunity and Neomalthusian Willingness: Boundaries, Shared Rivers, and Conflict," *International Interactions*, vol. 32, no. 1,

Some researchers developed tools to diagnose the level of competition in the hydropolitical relations among riparians. The most widely used analytical tools for doing this are scales that measure the level of conflict or cooperation between the riparians. Some examples are the Water Event Intensity Scale[25] developed upon the Basins at Risk Project, the Stages of Conflict Development created by NATO in 1999, and the Transboundary Water Interaction Nexus.[26] Some academic projects and research institutions are involved in this research as well, such as the Pacific Institute or the Oregon State University.[27]

Especially after the end of the Cold War, with a change in the definition of security, the issues of environment, water, and climate were included in the international

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2006; Theodora-Ismene Gizelis & Amanda Wooden, "Water Resources, Institutions, and Intrastate Conflict," *Political Geography*, vol. 29, no. 8, 2010, p.444. See, especially: Thomas Homer-Dixon, "On the Threshold: Environmental Changes as Causes of Acute Conflict," *International Security*, vol. 16, no. 2, 1991; Jan Selby, *Water, Power and Politics in the Middle East The Other Israeli–Palestinian Conflict* (London & New York: I.B. Tauris, 2003).

[25] Shira Yoffe, Aaron Wolf & Mark Giordano, "Conflict and Cooperation over International Freshwater Resources: Indicators of Basins at Risk," *JAWRA Journal of the American Water Resources Association*, vol. 39, 2003; S. Yoffe et al., "Geography of international water conflict and cooperation: Data sets and applications," *Water Resources Research*, vol. 40, no. W05S04, 2004.

[26] Naho Mirumachi & John Allan, "Revisiting Transboundary Water Governance: Power, Conflict Cooperation and the Political Economy," in *Proceedings from CAIWA International Conference on Adaptive and Integrated Water Management: Coping with Scarcity*., 2007; Naho Mirumachi in *Proceedings of the 5th International Water History Association Conference: Past and Futures of Water*., 2007.

[27] Peter Gleick & Matthew Heberger, "Water and Conflict: Events, Trends, and Analysis (2011-2012)," in P.H. Gleick et al., eds. *World's Water Volume 8: The Biennial Report on Freshwater Resources*, 2014, p.159; Aaron Wolf, Kerstin Stahl & Marcia Macomber, "Conflict and Cooperation within International River Basins: The Importance of Institutional Capacity," *Water Resources Update*, vol. 125, no. 2, 2003, p.1.

security studies.[28] An important aspect here is water scarcity,[29] exacerbated by climate change.

2.2.1. Water scarcity

Munia et al. define scarcity as the situation in which "local precipitation [in a region or a state] is insufficient to meet needs." In such cases, the state would be in need of "external water resources, both physical and virtual."[30] According to Arsel and Spoor, scarcity is a politically and socially constructed concept and needs to be addressed within "particular geographic, political economic and historical context." Thus, the meaning of water scarcity should be searched in both historical and current policies and practices.[31] The chapters of this study are designed in parallel with this view (Figure 2.1).

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[28] Peter Gleick, "Water and Conflict: Fresh Water Resources and International Security," *International Security*, vol. 18, no. 1, 1993, p.81; S. Yoffe et al., "Geography of international water conflict and cooperation: Data sets and applications," *Water Resources Research*, vol. 40, no. W05S04, 2004, p.2

[29] See, for a systematic literature review: Victoria Johnson, Rita Floyd, Ian Fitzpatrick & Leroy White, *What is the evidence that scarcity and shocks in freshwater resources can cause conflict instead of promoting collaboration in arid to subhumid hydroclimates?*, Collaboration for Environmental Evidence, 2010; V. Johnson, I. Fitzpatrick, R. Floyd & A. Simms, *What is the evidence that scarcity and shocks in freshwater resources cause conflict instead of promoting collaboration?*, Collaboration for Environmental Evidence, 2011.

[30] Hafsa Munia, et al., "How Downstream Sub-basins Depend on Upstream Inflows to Avoid Scarcity: Typology and Global Analysis of Transboundary Rivers," *Hydrology and Earth System Sciences*, 2017, p.1. See Chapter 2 for a discussion on virtual water trade.

[31] Murat Arsel & Max Spoor, "Follow the Water," in M. Arsel & M. Spoor, eds. *Water, environmental security and sustainable rural development: conflict and cooperation in Central Eurasia*, 2010, p.9.

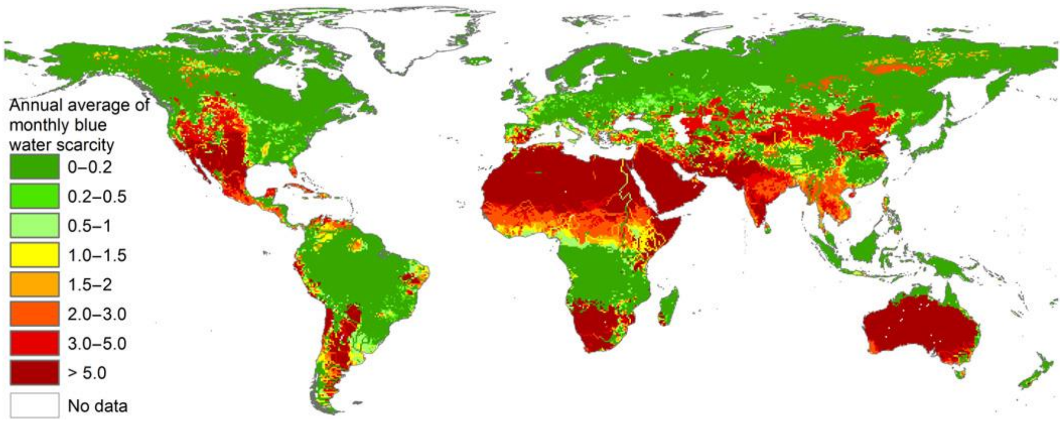

Figure 2.1. Annual average monthly blue water scarcity[32]

Based on concerns connected to water scarcity in some regions, especially in the Middle East and Africa, some researchers foresaw higher demand for already alarming water resources, as a result of increasing global population, along with a change in consumption patterns and a demand for continuous economic growth.[33] Recent research indicate to a risk of water scarcity in a wider geography throughout the world, affecting more than four billion people.[34] Some reasons exacerbate the existing water problems, according to Falkenmark. These can be summarized as: "complexity of water," "communication problems," "the environmental syndrome," "climatic differences," "blindness to water scarcity," and "upstream-downstream

[32] Mesfin Mekonnen & Arjen Hoekstra, "Four billion people facing severe water scarcity," *Science Advances*, vol. 2, no. 2, 2016.

[33] Anders Jägerskog, *Water Security: Origin and Foundations* (Los Angeles: Sage, 2015), pp.xxiii-xxv.

[34] Mesfin Mekonnen & Arjen Hoekstra, "Four billion people facing severe water scarcity," *Science Advances*, vol. 2, no. 2, 2016.

dichotomy." According to the author, water-induced conflict may arise, especially in Africa and the Middle East, unless urgent steps are taken. [35]

Besides, the scarcity of water may have economic consequences. According to a recent World Bank report, water scarcity and climate change may cause a retreat in the gross domestic product up to 6 percent in some regions by 2050, which, in turn, may contribute to or cause conflict.[36] In parallel, Gleditsch et al. found that water scarcity would increase the possibility of conflict in a dyadic relationship, particularly "when a river is shared across rather than along a border."[37] A river that is used for multiple purposes, such as irrigation, navigation, hydroelectricity tends to increase the interaction between dyads, which may lead to an increased likelihood of a conflict between them.[38] This means that a boundary river is not significantly related to water-related conflict, while a shared basin is more prone to conflict.[39]

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[35] Malin Falkenmark, "Global Water Issues Confronting Humanity," *Journal of Peace Research*, vol. 27, no. 2, 1990, pp.177-79.

[36] World Bank, *High and Dry: Climate Change, Water, and the Economy*, World Bank, 2016.

[37] Nils Gleditsch et al., "Conflicts Over Shared Rivers: Resource Scarcity or Fuzzy Boundaries?," *Political Geography*, vol. 25, no. 4, 2006, p.362. More recently, the findings of this were tested with improved databases. Brochmann and Gleditsch contended in 2012 that as almost all states in the world share at least one river basin, one has to take into consideration the question of "how a river basin is shared," or in short, the salience of a river. See: Marit Brochmann & Nils Gleditsch, "Shared Rivers and Conflict – A Reconsideration," *Political Geography*, vol. 31, no. 8, 2012, p.525. The subject of salience in international issue areas, including maritime and river issues, with relation to interstate conflict is discussed by: Paul Hensel, Sara Mitchell, Thomas Sowers & Clayton Thyne, "Bones of Contention: Comparing Territirial, Maritime, and River Issues," *The Journal of Conflict Resolution* , vol. 52, no. 1, 2008. See also: Paul Hensel, Sara Mitchell & Thomas Sowers, "Conflict Management of Riparian Disputes," *Political Geography*, vol. 25, no. 4, 2006.

[38] Marit Brochmann & Nils Gleditsch, "Shared Rivers and Conflict – A Reconsideration," *Political Geography*, vol. 31, no. 8, 2012, p.520.

[39] Nils Gleditsch et al., "Conflicts Over Shared Rivers: Resource Scarcity or Fuzzy Boundaries?," *Political Geography*, vol. 25, no. 4, 2006, p.378.

Delli Priscoli and Wolf argue that "shared water does lead to tensions, threats, and even to some localized violence."[40] While there is an evident tendency in the literature to link water and dispute, most papers on this subject reject the idea of all-out international water wars. As Menga contends, the "control of water resources is related to power dynamics and not to the idea of water wars." This idea has been reiterated in the academic literature since the early 1990s.[41] As some scholars observe, water alone is not a source of wars or violence. However, in cases when other political issues are involved with water issues, some ferocity may occur. In the words of Warner and Wegerich, "water is the occasion, not the reason, for conflict."[42] However, as Zeitoun and Warner famously emphasize, in a riparian relationship, "the absence of war does not mean the absence of conflict."[43] Numerous researchers conclude that it is almost clear that countries with a shared river have a higher risk of military disputes against each other.[44] Gleick thinks that water can be a reason for military conflict between countries. Also, water can be a means of warfare (in the form of attacking dams and water systems during wars).[45] Gleick gives four characteristics of water that would make it "a source of strategic rivalry." These are: "the degree of scarcity [of water], the extent to which the water supply is shared by more than one region or state, the relative power of the basin states,

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[40] Jerome Delli Priscoli & Aaron Wolf, *Managing and Transforming Water Conflicts* (Cambridge: Cambridge University Press, 2009), p.9.

[41] Filippo Menga, "Reconceptualizing Hegemony: The Circle of Hydro-Hegemony," *Water Policy*, vol. 18, no. 2, 2016, p.409.

[42] Jeroen Warner & Kai Wegerich, "Is Water Politics? Towards International Water Relations," in K. Wegerich & J. Warner, eds. *The Politics of Water: A Survey* 1st ed., 2010, p.7.

[43] Mark Zeitoun & Jeroen Warner, "Hydro-hegemony: A Framework for Analysis of Trans-Boundary Water Conflicts," *Water Policy*, vol. 8, no. 5, 2006, p.437.

[44] Hans Toset, Nils Gleditsch & Håvard Hegre, "Shared Rivers and Interstate Conflict," *Political Geography*, vol. 19, no. 8, 2000; Nils Gleditsch et al., "Conflicts Over Shared Rivers: Resource Scarcity or Fuzzy Boundaries?," *Political Geography*, vol. 25, no. 4, 2006, pp.362-63.

[45] Peter Gleick, "Water and Conflict: Fresh Water Resources and International Security," *International Security*, vol. 18, no. 1, 1993, p.83 and 84.

and the ease of access to alternative fresh water sources."[46] Accordingly, "the focus of security analysts must be *when* and *where* resource-related conflicts are most likely to arise, not *whether* environmental concerns can contribute to instability and conflict."[47] Petersen-Perlman et al. argue that conflict over water in a transboundary river basin is a result of a clash of interests and perceptions. The instances of water conflicts are likely to increase due to population growth and adverse impacts of climate change. According to authors, conflicts over water often occur not in the form of wars, but in the form of verbal and economically hostile actions and can be prevented through third-party involvement, application of international law, and through the establishment of institutions.[48]

On the other hand, not only inter-state conflict is likely to occur because of water, but also, intrastate or subnational crises may take place. Gleick and Herberger argue that one possible reason for that may be that there is an increased number of political and diplomatic tools that states could employ to prevent disputes. There are no such tools on subnational level, however.[49] According to Molden, future water conflicts will be between "pastoralists and herders, between farms and cities, between those upstream and those downstream."[50]

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[46] Peter Gleick, "Water and Conflict: Fresh Water Resources and International Security," *International Security*, vol. 18, no. 1, 1993, pp.84-85.

[47] Peter Gleick, "Water and Conflict: Fresh Water Resources and International Security," *International Security*, vol. 18, no. 1, 1993, pp.82-83, emphasis original.

[48] Jacob Petersen-Perlman, Jennifer Veilleux & Aaron Wolf, "International Water Conflict and Cooperation: Challenges and Opportunities," *Water International*, vol. 42, no. 2, 2017.

[49] Peter Gleick & Matthew Heberger, "Water and Conflict: Events, Trends, and Analysis (2011-2012)," in P.H. Gleick et al., eds. *World's Water Volume 8: The Biennial Report on Freshwater Resources*, 2014, p.159.

[50] David Molden, *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture* (London: Earthscan, International Water Management Institute & Comprehensive Assessment of Water Management in Agriculture (Program), 2007), p.2.

Some assessment methodologies were developed for physical water scarcity measurement since the 1970s. The 1974 model of Falkenmark and Lindh that estimates water withdrawal needs for various purposes was one of the forerunners[51] and further advanced in the next decades. Other examples were the models of the United Nations Food and Agriculture Organization and the Stockholm Environmental Institute developed in 1996 and 1997, respectively. Models using the grid method were introduced since then: The WaterGAP model of 1997 monitors 55 x 55 kilometers grids on earth surface in terms of water availability. The Global Water Availability Assessment developed in 1999 is another prominent tool.[52]

Some researchers linked physical assessment of water with social indicators, one example being the Social Water Stress/Scarcity Index of Ohlsson of 1998.[53] Criticizing the large grid assessment areas of previous studies, more recently, Sullivan proposed a Water Poverty Index linking water availability and accessibility to basic human development indicators such as health, poverty, or sanitation.[54] Some studies focus on the relationship between water stress in transboundary river basins and upstream water use. The study of Munia et al. found that upstream water use slightly increases the number of people in a basin that live under water stress. On the other

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[51] Malin Falkenmark & Gunnar Lindh, "How Can We Cope with the Water Resources Situation by the Year 2015?," *Ambio*, vol. 3, no. 3/4, 1974.

[52] See: Egon Dumont, et al., "Modelling Indicators of Water Security, Water Pollution and Aquatic Biodiversity in Europe," *Hydrological Sciences Journal*, vol. 57, no. 7, 2012.

[53] Leif Ohlsson, *Environment, Scarcity, and Conflict: A Study of Malthusian Concerns* (Göteborg: Department of Peace and Development Research, Göteborg University, 1999).

[54] Caroline Sullivan, "The Potential for Calculating a Meaningful Water Poverty Index," *Water International*, vol. 26, no. 4, 2001; Caroline Sullivan, "Calculating a Water Poverty Index ," *World Development : the Multi-Disciplinary International Journal Devoted to the Study and Promotion of World Development*, vol. 30, no. 7, 2002.

hand, the researchers found no statistically significant relationship between upstream water withdrawals and the occurrence of conflict.[55]

2.2.2. Power and hydro-hegemony

Power is an important point of interest in water-related conflict research. Following the three-dimensional power classification of Lukes,[56] suggested are various forms of power that have an impact on hydropolitics. These are: geographical power, material power, bargaining power and ideational power.[57] Cascão and Zeitoun conclude that the power of geography, i.e. being in the upstream of a basin, gives a state relative advantage in a hydropolitical relationship. Yet this geographical power alone is insufficient to be a hydro-hegemon. Material, bargaining, economic power, as well as international support must be combined to dominate the hydro-hegemonic relationship.[58] In contrary, employing the classification of Nye's hard power and soft power, Menga argues that geographical position is important, it "changes a country's ability to coerce," as an integral and important aspect of material power.[59]

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[55] H. Munia, et al., "Water Stress in Global Transboundary River Basins: Significance of Upstream Water Use on Downstream Stress," *Environmental Research Letters*, vol. 11, 2016, p.9.

[56] Mark Zeitoun et al., "Transboundary Water Interaction III: Contest and Compliance," *International Environmental Agreements: Politics, Law and Economics*, 2016; Mark Zeitoun & J. Allan, "Applying Hegemony and Power Theory to Transboundary Water Analysis," *Water Policy*, vol. 10, no. Supplement 2, 2008.

[57] Ana Cascão & Mark Zeitoun, "Power, Hegemony and Critical Hydropolitics," in A. Earle, A. Jägerskog & J. Öjendal, eds. *Transboundary Water Management: Principles and Practice*, 2010, pp.31-32.

[58] Ana Cascão & Mark Zeitoun, "Power, Hegemony and Critical Hydropolitics," in A. Earle, A. Jägerskog & J. Öjendal, eds. *Transboundary Water Management: Principles and Practice*, 2010, p.36.

[59] Filippo Menga, "Reconceptualizing Hegemony: The Circle of Hydro-Hegemony," *Water Policy*, vol. 18, no. 2, 2016, p.405.

Zeitoun and Warner endeavored in 2006 to establish a framework of hydro-hegemony, an analytical tool and analytical structure to account for water, power and conflict nexus between riparian states, by combining the concepts of power, hegemony, and the intensity of conflict.[60] The authors argued in 2008 that they applied the realist and critical IR theories to hydropolitics and tried to explore the "layered nature" of water and hegemony.[61] In 2016, Menga attempted a reconceptualization of the framework by proposing a new concept, the "circle of hydro-hegemony," by focusing more on hegemony than on power.[62]

Some authors argue that a "power asymmetry" can be advantageous for both sides in a riparian relationship. The weaker state in a hydro-hegemonic relationship can employ some of its powers (such as bargaining power) to challenge the position of the hegemon and create a more equitable relationship.[63] Alternatively, it can directly challenge the hegemon by undertaking large projects on its own or with the aid from the international donors.[64] On the other hand, as a reflection of the "hegemonic stability" theory of IR, some authors argue that the presence of a hegemon in a river basin provides stability in relations.[65]

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[60] Mark Zeitoun & Jeroen Warner, "Hydro-hegemony: A Framework for Analysis of Trans-Boundary Water Conflicts," *Water Policy*, vol. 8, no. 5, 2006, p.443 and 455.

[61] Jeroen Warner & Mark Zeitoun, "International Relations Theory and Water Do Mix: A Response to Furlong's Troubled Waters, Hydro-Hegemony and International Water Relations," *Political Geography*, vol. 27, 2008, p.809.

[62] Filippo Menga, "Reconceptualizing Hegemony: The Circle of Hydro-Hegemony," *Water Policy*, vol. 18, no. 2, 2016, p.402.

[63] Ana Cascão & Mark Zeitoun, "Power, Hegemony and Critical Hydropolitics," in A. Earle, A. Jägerskog & J. Öjendal, eds. *Transboundary Water Management: Principles and Practice*, 2010, p.40.

[64] Rawia Tawfik, "Reconsidering counter-hegemonic dam projects: the case of the Grand Ethiopian Renaissance Dam," *Water Policy*, vol. 19, no. 1, 2016.

[65] Mark Zeitoun, Naho Mirumachi & Jeroen Warner, "Transboundary Water Interaction II: The Influence of 'Soft' Power," *International Environmental Agreements: Politics, Law And Economics*, vol. 11, no. 2, 2011, p.169.

The power in riparian relations may be employed in three ways: First, the material or structural power can be employed, which does not only include military and hard power, but also some internationally accepted concepts such as the integrated water resources management (IWRM, see below). Such concepts can be used by hegemons to their own favor. Second, powerful actors may gain an upper hand in the bargaining process, where possible. Third, they may get the other party "believe that their predicaments are reasonable, and not worth questioning at all."[66]

On the other hand, power does not always translate into advantage in riparian relations. Closely related to tragedy of commons or resource curse approaches, there is strong evidence that a diversified economy has its own advantages over a resource-dependent economy. Therefore, being non-resource-dependent may give a significant advantageous position to a state in a river basin, especially when the relationship between the states is conflictual. Zeitoun and Allan argue that a diversified economy means strong "social adaptive capacity." According to the authors, "with social adaptive capacity an economy can nurture and combine its other capitals–manufactured, financial and human–to compensate for those in which it is deficient."[67]

In parallel with the severe criticism of the literature on water wars, a water-induced cooperation literature was developed,[68] although less sophisticated than the conflict

[66] Mark Zeitoun & J. Allan, "Applying Hegemony and Power Theory to Transboundary Water Analysis," *Water Policy*, vol. 10, no. Supplement 2, 2008, p.9.

[67] Mark Zeitoun & J. Allan, "Applying Hegemony and Power Theory to Transboundary Water Analysis," *Water Policy*, vol. 10, no. Supplement 2, 2008, p.11

[68] Ana Cascão & Mark Zeitoun, "Power, Hegemony and Critical Hydropolitics," in A. Earle, A. Jägerskog & J. Öjendal, eds. *Transboundary Water Management: Principles and Practice*, 2010, p.29

literature.[69] While the conflict literature is related to realism and realpolitik, the water-induced cooperation literature is linked with institutionalism on the one hand, and the green approach to the environmental IR theory on the other. Since the cooperation literature adopts a critical stance towards the concept of sovereignty, it sees an opportunity in this situation as water and environment problems may catalyze the peace by undermining the notion of sovereignty.[70]

2.3. Water-induced cooperation

In the literature, on the optimistic side are authors that argue water scarcity is more likely to cause cooperation and help "innovation, substitution, and flexible pricing of resources, particularly in developed countries."[71] Water-induced cooperation is possible with the involvement of institutions,[72] or the civil society.[73] Some scholars see institutions so important that the water conflicts are "institutionally driven."[74] According to this view, the "frequency, intensity and duration," as well as settlement practices (i.e. militarized or peaceful settlement) of conflicts stemming

[69] Mark Zeitoun & Naho Mirumachi, "Transboundary Water Interaction I: Reconsidering Conflict and Cooperation," *International Environmental Agreements: Politics, Law and Economics*, vol. 8, 2008, p.299.

[70] Murat Arsel & Max Spoor, "Follow the Water," in M. Arsel & M. Spoor, eds. *Water, environmental security and sustainable rural development: conflict and cooperation in Central Eurasia*, 2010, p.9.

[71] Nils Gleditsch et al., "Conflicts Over Shared Rivers: Resource Scarcity or Fuzzy Boundaries?," *Political Geography*, vol. 25, no. 4, 2006, p.364.

[72] Anton Earle, Anders Jägerskog & Joakim Öjendal, "Introduction: Setting the Scene for Transboundary Water Management Approaches," in A. Earle, A. Jägerskog & J. Öjendal, eds. *Transboundary Water Management: Principles and Practice*, 2010, p.2; Aaron Wolf, Kerstin Stahl & Marcia Macomber, "Conflict and Cooperation within International River Basins: The Importance of Institutional Capacity," *Water Resources Update*, vol. 125, no. 2, 2003, p.3.

[73] Pichamon Yeophantong, "River Activism, Policy Entrepreneurship and Transboundary Water Disputes in Asia," *Water International*, vol. 42, no. 2, 2017.

[74] Theodora-Ismene Gizelis & Amanda Wooden, "Water Resources, Institutions, and Intrastate Conflict," *Political Geography*, vol. 29, no. 8, 2010, p.445.

from shared rivers depend on institutions and water scarcity.[75] Institutions and regime types are crucial in determining the distribution of and access to water resources. Some scholars think that an increased level of democracy,[76] or an increased level of development[77] decreases the likelihood of intrastate conflict.

In 2006, *Political Geography* published a special issue on conflict and cooperation over international rivers. In those years, some studies based on large databases using a continuum that measured interstate conflict concluded that a transboundary river between two countries,[78] usually combined with water scarcity,[79] or a river that forms a boundary between two countries,[80] or with social inequalities,[81] contribute to the likelihood of an incidence of conflict. Some years ago, working at the "Basins at Risk Project," Yoffe et al. raised a criticism that most works on water and conflict focus on "most volatile basins" in the world and therefore found traces of conflict.[82] The scholars of the Project quantified the international water relations

[75] Paul Hensel, Sara Mitchell & Thomas Sowers, "Conflict Management of Riparian Disputes," *Political Geography*, vol. 25, no. 4, 2006, p.384 and 388.

[76] Theodora-Ismene Gizelis & Amanda Wooden, "Water Resources, Institutions, and Intrastate Conflict," *Political Geography*, vol. 29, no. 8, 2010, p.451.

[77] Nils Gleditsch et al., "Conflicts Over Shared Rivers: Resource Scarcity or Fuzzy Boundaries?," *Political Geography*, vol. 25, no. 4, 2006, p.379.

[78] Hans Toset, Nils Gleditsch & Håvard Hegre, "Shared Rivers and Interstate Conflict," *Political Geography*, vol. 19, no. 8, 2000.

[79] Kathryn Furlong, Nils Gleditsch & Håvard Hegre, "Geographic Opportunity and Neomalthusian Willingness: Boundaries, Shared Rivers, and Conflict," *International Interactions*, vol. 32, no. 1, 2006. Some authors see the possibility of using militarized force relatively higher. See: Paul Hensel, Sara Mitchell & Thomas Sowers, "Conflict Management of Riparian Disputes," *Political Geography*, vol. 25, no. 4, 2006.

[80] Nils Gleditsch et al., "Conflicts Over Shared Rivers: Resource Scarcity or Fuzzy Boundaries?," *Political Geography*, vol. 25, no. 4, 2006.

[81] Theodora-Ismene Gizelis & Amanda Wooden, "Water Resources, Institutions, and Intrastate Conflict," *Political Geography*, vol. 29, no. 8, 2010, p.444.

[82] Shira Yoffe, Aaron Wolf & Mark Giordano, "Conflict and Cooperation over International Freshwater Resources: Indicators of Basins at Risk," *JAWRA Journal of the American Water Resources Association*, vol. 39, 2003, p.1109.

between states, and found that between 1948 and 1999, cooperation over water was predominant globally.[83] Similarly, Wolf, Stahl, and Macomber observed riparian countries cooperate for regional development and mutual gains, while accepting that the nature of international politics is conflictual.[84] Depending on the Project database, the authors report that the incidents of cooperation outnumber the incidents of conflict over water resources.[85] According to the authors, conflicts may occur occasionally, yet a "violent conflict" is observed only rarely.[86] Earle, Jägerskog, and Öjendal contend that one may observe water-related disputes, yet these rarely turn into deeper conflicts.[87] Zeitoun et al. emphasize "soft power" in analyzing water-related conflicts. The authors contend that states use "words and ideas" instead of military means during water disputes.[88]

Some scholars on the side of cooperation tacitly accept the notion of hegemony and the presence of a hegemon. Furlong states that the water discourse recognizes that cooperation is only achievable in water basins if the hegemonic riparian consents

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[83] Shira Yoffe, Aaron Wolf & Mark Giordano, "Conflict and Cooperation over International Freshwater Resources: Indicators of Basins at Risk," *JAWRA Journal of the American Water Resources Association*, vol. 39, 2003, p.1112.

[84] Aaron Wolf, Kerstin Stahl & Marcia Macomber, "Conflict and Cooperation within International River Basins: The Importance of Institutional Capacity," *Water Resources Update*, vol. 125, no. 2, 2003, p.1.

[85] Aaron Wolf, Kerstin Stahl & Marcia Macomber, "Conflict and Cooperation within International River Basins: The Importance of Institutional Capacity," *Water Resources Update*, vol. 125, no. 2, 2003, p.2

[86] Shira Yoffe, "Basins At Risk: Conflict and Cooperation Over International Freshwater Resources" 2001, p.122.

[87] Anton Earle, Anders Jägerskog & Joakim Öjendal, "Introduction: Setting the Scene for Transboundary Water Management Approaches," in A. Earle, A. Jägerskog & J. Öjendal, eds. *Transboundary Water Management: Principles and Practice*, 2010, p.2.

[88] Mark Zeitoun, Naho Mirumachi & Jeroen Warner, "Transboundary Water Interaction II: The Influence of 'Soft' Power," *International Environmental Agreements: Politics, Law And Economics*, vol. 11, no. 2, 2011, p.161.

to it or "is coerced to do so" by an external power.[89] From this standpoint, this is a manifestation of the hegemonic stability theory prevalent in mainstream realist school of IR theory.[90] On the other hand, the hegemon-provided order may not always be the most desired outcome and has the potential of affecting the environmental situation negatively, because of lack of supervision and regulation. This not only degrades the environment, but also the economic growth and development conditions, as climate change influences economic activity, as noted by international organizations.[91]

In parallel, some international organizations work for establishing cooperative frameworks in the shared river basins. The first international center that focus on transboundary water management is the International Centre for Water Cooperation of the UNESCO.[92] Another example, the Stockholm International Water Institute (SIWI), which also hosts the International Centre for Water Cooperation, was founded in 1991 with the aim of finding solutions for better water governance "through international policy processes."[93] According to the SIWI, about one-third

[89] Kathryn Furlong, "Hidden Theories, Troubled Waters: International Relations, the 'Territorial Trap', and the Southern African Development Community's Transboundary Waters," *Political Geography*, vol. 25, no. 4, 2006, p.442.

[90] Kathryn Furlong, "Hidden Theories, Troubled Waters: International Relations, the 'Territorial Trap', and the Southern African Development Community's Transboundary Waters," *Political Geography*, vol. 25, no. 4, 2006, p.443.

[91] World Bank, High and Dry: Climate Change, Water, and the Economy, World Bank, 2016; M. Farid et al., After Paris: Fiscal, Macroeconomic, and Financial Implications of Climate Change, International Monetary Fund, 2016, pp.8-12.

[92] International Centre for Water Cooperation, "The ICWC," *UNESCO*, 2017, available at: www.internationalwatercooperation.org (accessed 5 October 2017).

[93] Stockholm International Water Institute, "About Us," *SIWI*, 2015, available at: www.siwi.org/about (accessed 5 October 2017).

of all the transboundary rivers lack "a cooperative management framework." International agreements do not suffice for preventing water-related disputes between riparians and therefore, mediation mechanisms should be established.[94]

2.3.1. Resource management

An important part of the water politics literature is on managing water resources. Water is "not a simple economic good; it is sometimes a public good, sometimes a private good, and mostly lies somewhere in-between."[95] There have been significant efforts in the literature to establish globally accepted frameworks for water resources management.

The understanding of water management and the approach to it has changed over time. The conceptualization of it varied from sustainable development to river basin management (RBM), from integrated water resources management (IWRM) to water governance.[96] One of the earliest examples of the "integrated approach" to water management was observed in the US in 1933 with the river basin management of the Tennessee Valley Authority,[97] which became a model for developing countries (see Chapters 4 and 6).

The RBM is one of the well-accepted systems of water management and has been in use in developed regions such as Canada and EU for a while. The system is the base of the EU Water Framework Directive adopted in 2000. It is defined as "the

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[94] Stockholm International Water Institute, "Cooperation Over Shared Waters," *SIWI*, 2015, available at: www.siwi.org/priority-area/transboundary-water-management/ (accessed 5 October 2017).

[95] Peter Rogers & Alan Hall, *Effective Water Governance*, Global Water Partnership/Swedish International Development Agency, 2003, available at: http://dlc.dlib.indiana.edu/dlc/handle/10535/4995 (accessed 10 September 2016), p.24

[96] Cecilia Tortajada, "Water Governance: A Research Agenda," *International Journal of Water Resources Development*, vol. 26, no. 2, 2010, p.313.

[97] Animesh Gain, Josselin Rouillard & David Benson, "Can Integrated Water Resources Management Increase Adaptive Capacity to Climate Change Adaptation? A Critical Review," *Journal of Water Resource and Protection*, vol. 5, 2013, p.12.

management of water systems as part of broader natural environment and in relation to their socio-economic environment."[98] In recent years, the literature was developed towards IWRM[99] and water governance. The reports and projects of international organizations usually refer to the well-known concepts of RBM, IWRM and more recently water governance as principles of managing the transboundary river systems for the benefit of all stakeholders. Since governance entails "effectively implementing socially acceptable allocation and regulation," it is a densely political[100] concept and deserves a place within political science. The International Water Management Institute published a report with the title "A Comprehensive Assessment of Water Management" in Agriculture in 2007 to give specific advice to policymakers in the position of water and water resources management.[101]

2.3.2. Integrated water resources management and water governance

IWRM has a long history and has been developing since the early twentieth century.[102] Biswas summarizes the history of the concept,[103] which was first suggested in the 1960s and was "rediscovered" in the 1990s by water professionals after being

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[98] Jen Nelles, "Wet vs Dry: Theorizing a Multilevel Water Framework for Canadian Communities," in *Annual Meeting of the Canadian Political Science Association*., 2008, p.18.

[99] See, for example: Asit Biswas, Olli Varis & Cecilia Tortajada, *Integrated Water Resources Management in South and South-East Asia* (New Delhi: Oxford University Press, 2005), Asit Biswas, Benedito Braga, Cecilia Tortajada & Marco Palermo, *Integrated Water Resources Management in Latin America* (Hoboken: Taylor and Francis, 2013).

[100] Peter Rogers & Alan Hall, *Effective Water Governance*, Global Water Partnership/Swedish International Development Agency, 2003, available at: http://dlc.dlib.indiana.edu/dlc/handle/10535/4995 (accessed 10 September 2016), p.4

[101] International Water Management Institute, Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture, 2007.

[102] Mark Giordano & Tushaar Shah, "From IWRM back to Integrated Water Resources Management," *International Journal of Water Resources Development*, vol. 30, no. 3, 2014, p.364.

[103] Asit Biswas, "Integrated Water Resources Management: Is It Working?," *International Journal of Water Resources Development*, vol. 24, no. 1, 2008; A. Montanari et al., ""Panta Rhei—Everything Flows": Change in hydrology and society—The IAHS Scientific Decade 2013–2022," *Hydrological Sciences Journal*, vol. 58, no. 6, 2013.

realized by only a few of them in the 1980s that the global water situation was not "as good as it appeared." The reason for the rediscovery was that the concept was poorly implemented before the 1990s. Then, it got the support of international organizations,[104] including the United Nations.[105] The World Summit on Sustainable Development in 2002 was among the first international platforms where leaders committed to preparing IWRM plans.[106]

As Biswas reminds, the most frequently used definition of IWRM was formulated by the Global Water Partnership (GWP). According to the GWP, IWRM is "a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems."[107] Hansson et al. summarizes the concept as "the antithesis of conventional, fractional and fragmented water management systems. Emphasis is put upon *integration* and *coordination*."[108]

The Dublin Agreement on IWRM suggests that water is demanded for various purposes, such as production, energy, agriculture, sanitation, etc. Thus, water demand and "threat to this resource" should be well addressed. This approach was embraced

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[104] Asit Biswas, "Integrated Water Resources Management: Is It Working?," *International Journal of Water Resources Development*, vol. 24, no. 1, 2008, p.7.

[105] Mark Giordano & Tushaar Shah, "From IWRM back to Integrated Water Resources Management," *International Journal of Water Resources Development*, vol. 30, no. 3, 2014, p.364.

[106] Peter Rogers & Alan Hall, *Effective Water Governance*, Global Water Partnership/Swedish International Development Agency, 2003, available at: http://dlc.dlib.indiana.edu/dlc/handle/10535/4995 (accessed 10 September 2016), p.16.

[107] Global Water Partnership, *Integrated Water Resources Management*, 2000, p.22.

[108] Stina Hansson, Sofie Hellberg & Joakim Ojendal, "Politics and Development in a Transboundary Watershed: The Case of the Lower Mekong Basin," in J. Öjendal, S. Hansson & S. Hellberg, eds. *Politics and Development in a Transboundary Watershed*, 2012, p.3. Emphasis original.

by significant national and international bodies. River basin-scale management approach is also a well-accepted aspect of IWRM. The most significant and less agreed-upon aspect of IWRM is governance. A multi-sector, multi-stakeholder approach is usually suggested, but its application is quite problematic.[109] Gain et al. suggests that IWRM should incorporate "adaptive capacity" as well, which, according to authors, increases the likelihood of equitable distribution of natural and economic resources, as well as fair access to healthcare, education, sanitation, etc.[110]

The basics of IWRM is understanding the mutual relationship between water and people.[111] IWRM got the support of numerous scholars because of its three aspects. First, it is a "comprehensive and holistic approach" for economically, ecologically, and socially sustainable water use; second, it is an approach based on river basin or catchment; and third, "it incorporates the elements of good governance."[112]

Another popular concept is water governance, which is, like IWRM, not a brand new concept.[113] The concept of governance gained prominence in the late twentieth century as a key for a possible solution of water-related problems. Like IWRM, academicians usually agree that there is not one and homogenous concept of water

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[109] Animesh Gain, Josselin Rouillard & David Benson, "Can Integrated Water Resources Management Increase Adaptive Capacity to Climate Change Adaptation? A Critical Review," *Journal of Water Resource and Protection*, vol. 5, 2013, p.14.

[110] Animesh Gain, Josselin Rouillard & David Benson, "Can Integrated Water Resources Management Increase Adaptive Capacity to Climate Change Adaptation? A Critical Review," *Journal of Water Resource and Protection*, vol. 5, 2013, p.15.

[111] A. Montanari et al., ""Panta Rhei—Everything Flows": Change in hydrology and society—The IAHS Scientific Decade 2013–2022," *Hydrological Sciences Journal*, vol. 58, no. 6, 2013, p.1260.,

[112] Animesh Gain, Josselin Rouillard & David Benson, "Can Integrated Water Resources Management Increase Adaptive Capacity to Climate Change Adaptation? A Critical Review," *Journal of Water Resource and Protection*, vol. 5, 2013, p.11.

[113] Peter Droogers & Johan Bouma, "Simulation Modelling for Water Governance in Basins," *International Journal of Water Resources Development*, vol. 30, no. 3, 2014, p.475.

governance that can be applied globally.[114] In its initial phases, the governance issue was assessed on local scales. Yet, during the course of time, the wide range and the complexity of water issues, as well as the need for an inclusive and synchronized global effort, have been widely accepted.[115]

For some authors water governance is a complex practice on state, institutions, private sector, and civil society levels.[116] Similarly, water governance includes "political, economic and social processes and institutions" for the good and reasonable use, development, and distribution of water resources.[117] Yet, as Biswas and Tortajada remind, the governance of water will be "more complex than ever before witnessed in human history" because of intensifying and increasing global water-related problems.[118] The definition given by the GWP in 2003 for the water governance is an evidence for this complexity. At The Hague World Water Forum in 2000 organized by GWP, this international organization contended that "the water crisis is often a crisis of governance,"[119] and defined water governance as a set of

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[114] Cecilia Tortajada, "Water Governance: Some Critical Issues," *International Journal of Water Resources Development*, vol. 26, no. 2, 2010, p.304.

[115] Heather Cooley et al., "Global Water Governance in the Twenty-First Century," in Peter Gleick et al. *The World's Water*, 2014, p.6.

[116] Cecilia Tortajada, "Water Governance: Some Critical Issues," *International Journal of Water Resources Development*, vol. 26, no. 2, 2010, p.298; Nicole Kranz, Antje Vorwerk & Rodrigo Vidaurre, "Towards Adaptive Water Governance: Observations from Two Transboundary River Basins," in *International Conference on Adaptive and Integrated Water Management (CAIWA), 12-15 November 2007.*, 2007.

[117] Cecilia Tortajada, "Water Governance: Some Critical Issues," *International Journal of Water Resources Development*, vol. 26, no. 2, 2010, p.299.

[118] Asit Biswas & Cecilia Tortajada, "Future Water Governance: Problems and Perspectives," *International Journal of Water Resources Development*, vol. 26, no. 2, 2010, p.130.

[119] Peter Rogers & Alan Hall, Global Water Partnership/Swedish International Development Agency, 2003, available at: http://dlc.dlib.indiana.edu/dlc/handle/10535/4995 (accessed 10 September 2016), p.15. The United Nations also accepted in 2003 that the water crisis is "a crisis of governance." See: Heather Cooley et al., "Global Water Governance in the Twenty-First Century," in Peter Gleick et al. *The World's Water*, 2014, pp.1-2.

"political, social, economic and administrative systems" for developing and managing water resources and delivering water services for all levels of society.[120]

Some authors suggest "multi-loop social learning"[121] together with widespread collaboration for effective and sustainable land and water resources governance. Also connected with the indigenous knowledge and change issues mentioned below, the authors stress the ability of indigenous groups to "integrate different sources of knowledge" in the search for collaborative efforts for water resources management,[122] and the importance of social learning for "managing social change," and "understanding the limitations of existing institutions and mechanisms of governance."[123]

Like the IWRM, the water governance has various interpretations too and various international organizations define the concept according to their own interests. On the other hand, Biswas and Tortajada contend that "accountability, transparency, participatory and decentralized decision making," "equity and fairness" as well as "proper allocation and management of resources to collective problems" are the key features of all the definitions and interpretations of the concept.[124] According to

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[120] Peter Rogers & Alan Hall, *Effective Water Governance*, Global Water Partnership/Swedish International Development Agency, 2003, available at: http://dlc.dlib.indiana.edu/dlc/handle/10535/4995 (accessed 10 September 2016), p.16.

[121] Wietske Medema, Arjen Wals & Jan Adamowski, "Multi-Loop Social Learning for Sustainable Land and Water Governance: Towards a Research Agenda on the Potential of Virtual Learning Platforms," *NJAS - Wageningen Journal of Life Sciences*, vol. 69, 2014; Claudia Pahl-Wostl & Nicole Kranz, "Water Governance in Times of Change," *Environmental Science & Policy*, vol. 13, no. 7, 2010; Claudia Pahl-Wostl *Global Environmental Change*, vol. 19, no. 3, 2009.

[122] Wietske Medema, Arjen Wals & Jan Adamowski, "Multi-Loop Social Learning for Sustainable Land and Water Governance: Towards a Research Agenda on the Potential of Virtual Learning Platforms," *NJAS - Wageningen Journal of Life Sciences*, vol. 69, 2014, p.24.

[123] Wietske Medema, Arjen Wals & Jan Adamowski, "Multi-Loop Social Learning for Sustainable Land and Water Governance: Towards a Research Agenda on the Potential of Virtual Learning Platforms," *NJAS - Wageningen Journal of Life Sciences*, vol. 69, 2014, pp.25-26.

[124]Asit Biswas & Cecilia Tortajada, "Future Water Governance: Problems and Perspectives," *International Journal of Water Resources Development*, vol. 26, no. 2, 2010, p.132; Cecilia

Cooley et al., multilateralism and international cooperation are "components" of governance. Global non-governmental and governmental organizations, regimes, actors, frameworks and agreements are the "instruments" of it.[125]

There are some factors that have an impact on water governance. These are, according to Tortajada, "population, urbanization, economic growth, energy generation, agricultural production, [as well as] globalization, free trade, immigration, advances in technology, […] changing management paradigms, and evolving social attitudes and perceptions."[126]

Since the IWRM and water governance literatures are closely related to the efforts of international donor organizations, these organizations closely follow, produce and support the studies in this literature. Despite all the efforts, some research concludes, the funding for water sector is quite low. Some new funders joined the traditional Western funders more recently, such as companies from Thailand, Malaysia, Russia, China or Vietnam. Yet, they are not sensitive enough to environmental and social standards in their funding activities.[127] Further problems of global water governance efforts are: inadequacy of efforts for water-data gathering; non-transparency of water sector; lack of consensus on how to create and implement agreements on transboundary waters (the 1997 UN convention on water has not obtained enough signatures to enter into force); and lack of flexibility in the existing inter-basin agreements.

Tortajada, "Water Governance: Some Critical Issues," *International Journal of Water Resources Development*, vol. 26, no. 2, 2010, p.306.

[125] Heather Cooley et al., "Global Water Governance in the Twenty-First Century," in Peter Gleick et al. *The World's Water*, 2014, p.6.

[126] Cecilia Tortajada, "Water Governance: A Research Agenda," *International Journal of Water Resources Development*, vol. 26, no. 2, 2010, p.311.

[127] Heather Cooley et al., "Global Water Governance in the Twenty-First Century," in Peter Gleick et al. *The World's Water*, 2014, p.10.

Established long ago, the water governance approach needs some updates. Cooley et al. argue that intergovernmental organizations need a leadership and coordination to achieve effective water governance performance globally. Globally, there are some important organizations that are involved water issues, such as the Food and Agriculture Organization (FAO), the United Nations Environment Programme (UNEP), the United Nations Development Programme (UNDP), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations International Children's Emergency Fund (UNICEF), the World Health Organization (WHO), the World Meteorological Organization (WMO).[128]

2.4. Criticism to conflict- and cooperation-based approaches

The critical hydropolitics challenges the dominance of both conflict-based realism and Malthusian approaches to natural resource policies in the literature. The main research design of the literature on conflict and cooperation is seeking to find a statistically significant relationship between shared water bodies and interstate conflict. This approach is usually one-directional, testing the presence of a shared river causing conflict between states. As Gizelis and Wooden contend, the assumption that shared rivers or scarcity of water automatically leads to conflict is problematical. The setbacks of this "automatism" are that it disregards the role of institutions, adaptation possibilities, and politics.[129] Arsel and Spoor contend that both "water wars" and "water for peace" are deterministic approaches and have their own limitations.[130] Some authors argue that conflict and cooperation based approaches are

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[128] Heather Cooley et al., "Global Water Governance in the Twenty-First Century," in Peter Gleick et al. *The World's Water*, 2014, pp.7-8.

[129] Theodora-Ismene Gizelis & Amanda Wooden, "Water Resources, Institutions, and Intrastate Conflict," *Political Geography*, vol. 29, no. 8, 2010, p.445.

[130] Mark Zeitoun & Jeroen Warner, "Hydro-hegemony: A Framework for Analysis of Trans-Boundary Water Conflicts," *Water Policy*, vol. 8, no. 5, 2006, p.298; Murat Arsel & Max Spoor, "Follow the Water," in M. Arsel & M. Spoor, eds. *Water, environmental security and sustainable rural development: conflict and cooperation in Central Eurasia*, 2010, p.10.

mostly biased and as they focus on an ongoing change in the nature of hydropolitics,[131] while some stress the coexistence of cooperation and conflict in water-related issues.[132] The cooperative end of the spectrum entails "shared control," while the competitive end involves "contested control" of transboundary rivers.[133]

Critical environmental studies and feminism have a share in this opposition camp.[134] As Sullivan contends, economic growth and wellbeing have had a privileged place in human history. This is partly a result of the lack of knowledge about ecosystem complexity. The growth economics assumed that "man-made and natural capital can infinitely be substituted," although it is "physically impossible,"[135] and as the environmental crisis may impede further economic crisis, the notion of economic development must be redefined.[136] This aspect of water policies is discussed in some detail in the following chapter.

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[131] Ana Cascão & Mark Zeitoun, "Power, Hegemony and Critical Hydropolitics," in A. Earle, A. Jägerskog & J. Öjendal, eds. *Transboundary Water Management: Principles and Practice*, 2010, p.29

[132] See: Anders Jägerskog, *Water Security: Origin and Foundations* (Los Angeles: Sage, 2015), p.xxvi; Mark Zeitoun & Naho Mirumachi, "Transboundary Water Interaction I: Reconsidering Conflict and Cooperation," *International Environmental Agreements: Politics, Law and Economics*, vol. 8, 2008.

[133] Ana Cascão & Mark Zeitoun, "Power, Hegemony and Critical Hydropolitics," in A. Earle, A. Jägerskog & J. Öjendal, eds. *Transboundary Water Management: Principles and Practice*, 2010, pp.31-32.

[134] Raymond Williams, *Problems in Materialism and Culture: Selected Essays* (London: Verso, 1980), p.84, cited in Tom Jagtenberg & David McKie, *Eco-impacts and the Greening of Postmodernity: New Maps for Communication Studies, Cultural Studies and Sociology* (Thousand Oaks, Calif: SAGE Publications, 1996), pp.7-13.

[135] Caroline Sullivan, "Calculating a Water Poverty Index ," *World Development : the Multi-Disciplinary International Journal Devoted to the Study and Promotion of World Development*, vol. 30, no. 7, 2002, p.1198.

[136] Kevin Wehr, *America's Fight over Water: The Environmental and Political Effects of Large-Scale Water Systems* (New York and London: Routledge, 2004), p.11; Chris Sneddon & Coleen Fox, "Rethinking Transboundary Waters: A Critical Hydropolitics of the Mekong Basin," *Political Geography*, vol. 25, no. 2, 2006.

2.4.1. Water in a changing environment

As the positivist approaches to the IR theory are often criticized[137] for having limitations of accounting for change,[138] the realism- and institutionalism-inspired water studies have the risk of underestimating the change in the hydrological research,[139] as well as the change in the nature of relationship between water and people. Climate change is the biggest and most important of environmental changes and has a decisive role in this process.[140] Further important elements of this change are water demand, which increases due to population growth, population movements from rural to urban areas, and the continuous economic growth[141] and the resulting shift toward more meat-based diets.[142] This change necessitates some steps to be taken:

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[137] One of the prominent critics of positivism, James Der Derian, argued in 1989 that post-structural practices "challenged the cognitive validity, empirical objectivity, and universalist and rationalist claims of idealist, realist and neorealist schools alike of [IR theory]." See: Ole Weaver, "The Rise and Fall of the Inter-Paradigm Debate," in S. Smith, K. Booth & M. Zalewski, eds. *International Theory: Positivism and Beyond*, 1996, pp.164-66; James Der Derian, *International/Intertextual Relations: Postmodern Readings of World Politics* (New York: Lexington Books, 1989), p.ix.

[138] Jutta Brunnée & Stephen Toope, "The Changing Nile Basin Regime: Does Law Matter?," *Harvard International Law Journal*, vol. 43, no. 1, 2002, p.111. See also: Robert Cox, "Social Forces, States and World Orders: Beyond International Relations Theory," *Millennium - Journal of International Studies*, vol. 10, no. 2, 1981; Piers Blaikie, "Post-modernism and Global Environmental Change," *Global Environmental Change*, vol. 6, no. 2, 1996, p.81.

[139] A. Montanari et al., "“Panta Rhei—Everything Flows”: Change in hydrology and society—The IAHS Scientific Decade 2013–2022," *Hydrological Sciences Journal*, vol. 58, no. 6, 2013, p.1257 and 1259.

[140] Claudia Pahl-Wostl & Nicole Kranz, "Water Governance in Times of Change," *Environmental Science & Policy*, vol. 13, no. 7, 2010, p.567.

[141] Heather Cooley et al., "Global Water Governance in the Twenty-First Century," in Peter Gleick et al. *The World's Water*, 2014, p.1; A. Montanari et al., "“Panta Rhei—Everything Flows”: Change in hydrology and society—The IAHS Scientific Decade 2013–2022," *Hydrological Sciences Journal*, vol. 58, no. 6, 2013, p.1258.

[142] Heather Cooley et al., "Global Water Governance in the Twenty-First Century," in Peter Gleick et al. *The World's Water*, 2014, p.1; Colin Green, *Handbook of Water Economics: Principles and Practice* (W.Sussex: John Wiley & Sons, 2003), p.277.

"mobilizing more water" and "managing water demand."[143] For some, more radical steps are in order: a shift of paradigm is necessary to overcome the issues of physical and social change.[144]

Water changes its surrounding in a physical manner as well. Evaporative cooling and erosion are ways in which water changes the environment. As Montanari et al. state, an important concept is entropy, especially in the river systems. "Flow and evolution in nature, including life, are inevitably associated with an increase of entropy and closely related to change."[145] As entropy increases, disorder and uncertainty in a system increase as well. The changes in nature are always "unpredictable in deterministic terms,"[146] and this is how hydrology and social theory interact. Critical theories in social sciences usually approach the determinism of structural theories with a suspicion.

Montanari et al. stress that "unpredictability is strictly related to indeterminacy and uncertainty, therefore representing a relevant limitation for the practical application of hydrological sciences to management and policy development."[147] In hydrological systems, important changes are induced by climate change and human activity. Humans have always settled near water resources and this contributed to their development. This often resulted with water resources degradation and sustainability

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143 A. Montanari et al., "“Panta Rhei—Everything Flows”: Change in hydrology and society—The IAHS Scientific Decade 2013–2022," *Hydrological Sciences Journal*, vol. 58, no. 6, 2013, p.1259. Water supply and demand is evaluated in some detail in Chapter 2.

144 Claudia Pahl-Wostl & Nicole Kranz, "Water Governance in Times of Change," *Environmental Science & Policy*, vol. 13, no. 7, 2010, p.567; Claudia Pahl-Wostl, "A Conceptual Framework for Analysing Adaptive Capacity and Multi-Level Learning Processes in Resource Governance Regimes," *Global Environmental Change*, vol. 19, no. 3, 2009, p.354.

145 A. Montanari et al., "“Panta Rhei—Everything Flows”: Change in hydrology and society—The IAHS Scientific Decade 2013–2022," *Hydrological Sciences Journal*, vol. 58, no. 6, 2013, p.1264.

146 Demetris Koutsoyiannis, "Hydrology and change," *Hydrological Sciences Journal*, vol. 58, no. 6, 2013, p.1180.

147 A. Montanari et al., "“Panta Rhei—Everything Flows”: Change in hydrology and society—The IAHS Scientific Decade 2013–2022," *Hydrological Sciences Journal*, vol. 58, no. 6, 2013, p.1264.

problems. The exploitation of water resources is only one aspect of the question. According to Montanari et al. other “feedbacks” that are related to reservoirs and dams, irrigation canals, flood risk analysis, etc. are only “poorly understood.”[148]

The questioning of official data and knowledge brings the issue of local knowledge[149] to the foreground in the transboundary water and theoretical IR studies. Nakashima et al. defined traditional knowledge as “the knowledge and know-how accumulated across generations, and renewed by each new generation, which guide human societies in their innumerable interactions with their surrounding environment.”[150] On the methodological level, Raadgever and Mostert distinguish two types of knowledge production. The first type is based on positivist epistemology and usually executed by academia and professionals. Since the 1980s, on the other hand, another type of knowledge production based on constructivist epistemology is gaining prominence. With the prominence of the latter, not a single type of knowledge is accepted as reflecting an objective and certain truth and the first type of knowledge must confront with other knowledge types, including local and experimental knowledge.[151]

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148 A. Montanari et al., "“Panta Rhei—Everything Flows”: Change in hydrology and society—The IAHS Scientific Decade 2013–2022," *Hydrological Sciences Journal*, vol. 58, no. 6, 2013, p.1264.

149 Tom Jagtenberg & David McKie, *Eco-impacts and the Greening of Postmodernity: New Maps for Communication Studies, Cultural Studies and Sociology* (Thousand Oaks, Calif: SAGE Publications, 1996), p.16.

150 Douglas Nakashima et al., *Weathering Uncertainty: Traditional Knowledge for Climate Change Assessment and Adaptation* (Paris and Darwin: UNESCO and United Nations University, 2012), p.7.

151 G. Raadgever & E. Mostert, "The Role of Expert Knowledge in Collaborative Water Management," in *International Conference on Integrated and Adaptive Water Management*., 2007, p.8.

Knowledge is one of the most crucial yet mostly biased aspect of water studies. The data or statistics created by the official sources are usually linked to states and reflect state interest, especially when the data is about a transboundary water body.[152] Zeitoun and Allan argue that in the international arena, the absence of rule of law and the presence of "near-anarchic and poorly informed circumstances" lead to the construction of knowledge by the more powerful riparian in a river basin. It is this constructed knowledge that usually determines the distribution of resources.[153] In a similar vein, Barnes shows how uncertain data may be, with regards to environmental indicators, such as climate change. Also, she analyses how this uncertainty in the data is exploited by the scientists in a subjective manner, in accordance with some certain interests.[154]

The issue of knowledge links to the literature on local or indigenous knowledge. Especially development studies and theories usually refer to indigenous knowledge. The book of Scott is an example of an ignorance of indigenous knowledge in modern world projects.[155] International and national organizations and networks have developed an interest in the subject in terms of food and biodiversity[156] and climate

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[152] Mark Zeitoun & J. Allan, "Applying Hegemony and Power Theory to Transboundary Water Analysis," *Water Policy*, vol. 10, no. Supplement 2, 2008, pp.3-4.

[153] Mark Zeitoun & J. Allan, "Applying Hegemony and Power Theory to Transboundary Water Analysis," *Water Policy*, vol. 10, no. Supplement 2, 2008, p.4.

[154] Jessica Barnes, "Uncertainty in the Signal: Modelling Egypt's Water Futures," *Environmental Futures*, 2016.

[155] James Scott, *Seeing Like A State: How Certain Schemes to Improve the Human Condition Have Failed* (New Haven: Yale University Press, 1998). See also: Heather Hoag, *Developing the Rivers of East and West Africa: An Environmental History* (London: Bloomsbury, 2013). The emphasis on local knowledge has been an important subject of discussion in the post-Cold War era literature, particularly as a part of the critique of modernist development projects. See, for example: Mark Hobart, *An Anthropological Critique of Development: The Growth of Ignorance* (London: Routledge, 1993); Marybeth Martello, "A Paradox of Virtue?: 'Other' Knowledges and Environment-Development Politics," *Global Environmental Politics*, vol. 1, no. 3, 2001, pp.114-41.

[156] Danielle Nierenberg & Tasnim Abdi, "Celebrating International Day of the World's Indigenous Peoples 2016," *Foodtank*, 2016, available at: http://foodtank.com/news/2016/08/celebrating-international-day-of-the-worlds-indigenous-peoples-2016 (accessed 10 August 2016).

change.[157] Since the early 1990s, the topic gained global recognition with the Earth Summit in Rio, Brazil, in 1992.[158]

The World Bank commenced a program called "Indigenous Knowledge for Development" in 1998 in order to "help learn from community-based knowledge systems and development practices, and to incorporate them into Bank-supported programs."[159] Especially the African Regional Office of the Bank advocated that indigenous knowledge can be a significant input in development strategies and policies,[160] especially where the Western and scientific knowledge failed to bring about "sustainable development,"[161] which was usually "linked to, or equated with, modernization."[162]

Droogers and Bouma argue that "water-related problems are diverse and location-specific."[163] Yet, "global approaches ignore differences at smaller spatial scales,

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[157] Douglas Nakashima et al., *Weathering Uncertainty: Traditional Knowledge for Climate Change Assessment and Adaptation* (Paris and Darwin: UNESCO and United Nations University, 2012).

[158] United Nations Inter-Agency Support Group, Thematic Paper on the Knowledge of Indigenous Peoples and Policies for Sustainable Development: updates and trends in the Second Decade of the World's Indigenous People, 2014, available at: http://www.un.org/en/ga/president/68/pdf/wcip/IASG%20Thematic%20Paper_%20Traditional%20Knowledge%20-%20rev1.pdf (accessed 10 August 2016), p.2.

[159] World Bank, *Indigenous Knowledge: Local Pathways to Global Development*, Knowledge and Learning Group, 2004a, available at: http://www.worldbank.org/afr/ik/ikcomplete.pdf, p.vii.

[160] Nicolas Gorjestani, *Indigenous Knowledge for Development: Opportunities and Challenges*, The World Bank, 2001, available at: http://www.worldbank.org/afr/ik/ikpaper_0102.pdf, p.1.

[161] Arun Agrawal, "Dismantling the Divide between Indigenous and Scientific Knowledge," *Development and Change*, vol. 26, no. 3, 1995, p.413.

[162] Mark Hobart, "Introduction: the growth of ignorance?," in Mark Hobart *An Anthropological Critique of Development: The Growth of Ignorance*, 2002, p.5.

[163] Peter Droogers & Johan Bouma, "Simulation Modelling for Water Governance in Basins," *International Journal of Water Resources Development*, vol. 30, no. 3, 2014, p.1.

covering countries, regions and basins."[164] Similarly, Cooley et al. argue that for the solution of water-related issues, "knowledge and technology transfer efforts [have been] largely top-down." On the other hand, recent trends indicate that there is a growing consensus that "technology is developed and crafted according to local circumstances, which can differ dramatically from one region to another."[165]

As Materer et al. notes, indigenous knowledge does not belong to an ethnicity or tribe, but to the people living in a certain geography. The knowledge is therefore "produced from its surroundings, the economic and social activities, and the unique environment, both social and physical aspects."[166] Raadgever and Mostert make a distinction between "expert knowledge" and "other" types of knowledge, including local knowledge. Expert knowledge "is strongly influenced by the goals and perspectives of the producers and users of knowledge."[167] Besides subjectivity, expert knowledge has the potential of reflecting the interests of the strong or more powerful side. On the other hand, as some authors argued, distinguishing between other types and indigenous knowledge is not easy.[168]

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[164] Peter Droogers & Johan Bouma, "Simulation Modelling for Water Governance in Basins," *International Journal of Water Resources Development*, vol. 30, no. 3, 2014, p.2.

[165] Heather Cooley et al., "Global Water Governance in the Twenty-First Century," in Peter Gleick et al. *The World's Water*, 2014, p.10.

[166] Susan Materer, Corinne Valdivia & Jere Gilles, *Indigenous Knowledge Systems: Characteristics and Importance to Climatic Uncertainty*, College of Agriculture, Food & Natural Resources, 2001, p.3.

[167] G. Raadgever & E. Mostert, "The Role of Expert Knowledge in Collaborative Water Management," in *International Conference on Integrated and Adaptive Water Management.*, 2007, p.8.

[168] Arun Agrawal, "Dismantling the Divide between Indigenous and Scientific Knowledge," *Development and Change*, vol. 26, no. 3, 1995, p.422; Susan Materer, Corinne Valdivia & Jere Gilles, *Indigenous Knowledge Systems: Characteristics and Importance to Climatic Uncertainty*, College of Agriculture, Food & Natural Resources, 2001, p.4.

2.4.2. Criticism to IWRM and water governance

As stated above, the IWRM and water governance are not new frameworks that have been studied for decades, and critical voices are raised in the literature. The *International Journal of Water Resources Development* published a special issue on IWRM in 2014. The editorial introduction of this volume recognizes that IWRM, governance and sustainable development concepts had "no visible impact on natural resources development."[169] Likewise, it has many critical articles that urge for a reconsideration or a reformulation of the concept. Giordano and Shah criticize the implementation of the concept for becoming an end itself, instead of a means.[170] Droogers and Bouma are also skeptical about the earlier version of IWRM, which tried to combine "technical and socioeconomic approaches" as to build principles of water management. Rather, they follow a more recent trend in the water management literature and advocate, along with other authors, an extended version of the concept that includes blue and green water too.[171] Other authors also propose new approaches. Araral and Wang suggest, for instance, "a second-generation multidisciplinary research agenda," to IWRM and water governance using the analytical tools provided by public economics, institutional economics, political economy and public administration. The authors argue that the emphasis of public economy on market failures and the theory of commons, as well as the emphasis of new institutional economics on transaction costs would help understanding the failures of current water governance processes and develop new approaches to it.[172]

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[169] Cecilia Tortajada, "IWRM Revisited: From Concept to Implementation," *International Journal of Water Resources Development*, vol. 30, no. 3, 2014, p.361.

[170] Mark Giordano & Tushaar Shah, "From IWRM back to Integrated Water Resources Management," *International Journal of Water Resources Development*, vol. 30, no. 3, 2014, p.365.

[171] Peter Droogers & Johan Bouma, "Simulation Modelling for Water Governance in Basins," *International Journal of Water Resources Development*, vol. 30, no. 3, 2014, p.475.

[172] Eduardo Araral & Yahua Wang, "Water Governance 2.0: A Review and Second Generation Research Agenda," *Water Resources Management*, vol. 27, no. 11, 2013.

Similarly, Biswas has a critical attitude towards IWRM and contend that water problems are not globally homogeneous and change over time and space. Since water problems are being increasingly interconnected, the ambiguous and popular concept of IWRM would not be able to solve all the problems in practice regardless of time and space.[173] For managing change and enabling sustainable development, which itself is a "continuous process of change,"[174] some authors[175] support the application of concepts, such as the "transition management" or "transitional action" as an approach for managing complex social change.[176] Transition management aims at "long-term anticipative and innovative thinking and acting, as well as at system innovation and system improvement."[177] An important characteristic of transition management is a "gradual approach," that seeks innovation by avoiding vast changes and consequent social resistance and high economic costs.[178]

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173 Asit Biswas, "Integrated Water Resources Management: Is It Working?," *International Journal of Water Resources Development*, vol. 24, no. 1, 2008, pp.5-13.

174 René Kemp, Derk Loorbach & Jan Rotmans, "Transition Management as a Model for Managing Processes of Co-evolution Towards Sustainable Development," *The International Journal of Sustainable Development & World Ecology*, vol. 14, no. 1, 2007, p.2.

175 René Kemp, Derk Loorbach & Jan Rotmans, "Transition Management as a Model for Managing Processes of Co-evolution Towards Sustainable Development," *The International Journal of Sustainable Development & World Ecology*, vol. 14, no. 1, 2007.

176 Jan Rotmans, René Kemp & Marjolein Asselt, "Transition Management: a promising policy perspective," in M. Decker, ed. *Interdisciplinarity in Technology Assessment: Implementation and Its Chances and Limits*, 2001, p.194.

177 Jan Rotmans, René Kemp & Marjolein Asselt, "Transition Management: a promising policy perspective," in M. Decker, ed. *Interdisciplinarity in Technology Assessment: Implementation and Its Chances and Limits*, 2001, p.176

178 Jan Rotmans, René Kemp & Marjolein Asselt, "Transition Management: a promising policy perspective," in M. Decker, ed. *Interdisciplinarity in Technology Assessment: Implementation and Its Chances and Limits*, 2001, p.182.

Suggesting an "adaptive" water governance,[179] Kranz et al. assess the regime type.[180] Accordingly, five "regime elements" are central for an ideal condition in transboundary water management. These regime types are bases for delineating the "adaptive capacity" of regime type.[181] These elements include, first, "actor networks," multi-level governance structures including state, academia, donor organizations, NGOs, and other stakeholders on local, regional and international levels; "legal frameworks," which are relatively inflexible, fragmented, and subordinate to national laws; policies developed in accordance with the legal frameworks to implement laws (these are rather more flexible); management and coordination of information from various sources; and financial adequacy.[182] Kranz et al. also focus on the concept of "transition" based on the levels (micro, meso and macro) conceptualized by Rotmans et al.[183] and developed by Kemp et al.[184] According to the authors, the main challenge is to overcome the inflexible structures at the meso level. There is a dialectical relationship between micro and macro levels, in which changes on micro level can affect a change on macro level or a change on micro level can trigger a greater change on macro level. However, change on macro level

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[179] Claudia Pahl-Wostl, "A Conceptual Framework for Analysing Adaptive Capacity and Multi-Level Learning Processes in Resource Governance Regimes," *Global Environmental Change*, vol. 19, no. 3, 2009, p.354.

[180] Nicole Kranz, Antje Vorwerk & Rodrigo Vidaurre, "Towards Adaptive Water Governance: Observations from Two Transboundary River Basins," in *International Conference on Adaptive and Integrated Water Management (CAIWA), 12-15 November 2007*., 2007.

[181] Nicole Kranz, Antje Vorwerk & Rodrigo Vidaurre, "Towards Adaptive Water Governance: Observations from Two Transboundary River Basins," in *International Conference on Adaptive and Integrated Water Management (CAIWA), 12-15 November 2007*., 2007, p.4.

[182] Nicole Kranz, Antje Vorwerk & Rodrigo Vidaurre, "Towards Adaptive Water Governance: Observations from Two Transboundary River Basins," in *International Conference on Adaptive and Integrated Water Management (CAIWA), 12-15 November 2007*., 2007, pp.3-6.

[183] Jan Rotmans, René Kemp & Marjolein Asselt, "Transition Management: a promising policy perspective," in M. Decker, ed. *Interdisciplinarity in Technology Assessment: Implementation and Its Chances and Limits*, 2001.

[184] René Kemp, Derk Loorbach & Jan Rotmans, "Transition Management as a Model for Managing Processes of Co-evolution Towards Sustainable Development," *The International Journal of Sustainable Development & World Ecology*, vol. 14, no. 1, 2007.

is seen only rarely, yet once seen, these often translate into important changes with considerable consequences. An important characteristic of such changes is "a relatively high degree of uncertainty."[185] In terms of water management, ontological and epistemological uncertainties may apply. While the former originates from "inherent variability of the system," the latter originates from "imperfect knowledge of the system." Uncertainties may arise on various stages in terms of water management, for example, at the initial stage, when defining management and problematic issues; or at the implementation stage of an IWRM or water governance framework.[186]

The Management and Transition Framework was suggested by some authors to analyze multi-level water systems governance, by integrating the concepts of adaptive management, social learning and regime transition and "Institutional Analysis and Development Framework (IAD)" developed in 2005.[187] Adaptive management refers to a systematic and active learning process that takes into account "changes in external factors in a pro-active manner."[188] Social learning is defined as "learning of the social entity as a whole," while the IAD has been developed to analyze the

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[185] Nicole Kranz, Antje Vorwerk & Rodrigo Vidaurre, "Towards Adaptive Water Governance: Observations from Two Transboundary River Basins," in *International Conference on Adaptive and Integrated Water Management (CAIWA), 12-15 November 2007*., 2007, p.7.

[186] Nicole Kranz, Antje Vorwerk & Rodrigo Vidaurre, "Towards Adaptive Water Governance: Observations from Two Transboundary River Basins," in *International Conference on Adaptive and Integrated Water Management (CAIWA), 12-15 November 2007*., 2007, p.7.

[187] Claudia Pahl-Wostl, Georg Holtz, Britta Kastens & Christian Knieper, "Analzyzing Complex Water Governance Regimes: The Management and Transition Framework," *Environmental Science & Policy*, vol. 13, no. 7, 2010, pp.571-74.

[188] Claudia Pahl-Wostl, Georg Holtz, Britta Kastens & Christian Knieper, "Analzyzing Complex Water Governance Regimes: The Management and Transition Framework," *Environmental Science & Policy*, vol. 13, no. 7, 2010, p.573.

role of institutions based on game theory and rational choice approaches.[189] Adaptive management takes the two important and less studied aspects of water management, change and uncertainty, into consideration and foresees to “learn from the outcomes of the implemented policies.”[190] In 2009, *Ecology and Society* published a special feature on adaptive management and change.[191] The editorial article suggests that although water management systems were built to reduce uncertainty and complexity, human involvement makes uncertainty unavoidable.[192]

2.5. The nexus approach

The technical as well as political nexus literature is developed with contributions from water professionals as well as organizations that analyze water-related issues from the perspective of various issue linkages. The contributions usually focus on the connections of water with energy, together with environment,[193] pollution,[194]

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[189] Claudia Pahl-Wostl, Georg Holtz, Britta Kastens & Christian Knieper, "Analzyzing Complex Water Governance Regimes: The Management and Transition Framework," *Environmental Science & Policy*, vol. 13, no. 7, 2010, pp.573-74.

[190] G. Raadgever et al., "Assessing Management Regimes in Transboundary River Basins: Do They Support Adaptive Management?," *Ecology and Society*, vol. 13, no. 1, 2008.

[191] Ecology and Society, "New Methods for Adaptive Water Management," *Ecology and Society*, 2009, available at: http://www.ecologyandsociety.org/issues/view.php?sf=31 (accessed 16 September 2016).

[192] Claudia Pahl-Wostl, Jan Sendzimir & Paul Jeffrey, "Resources Management in Transition," *Ecology and Society*, vol. 14, no. 1, 2009.

[193] World Bank, *High and Dry: Climate Change, Water, and the Economy*, World Bank, 2016.

[194] Prashant Kumar & Devendra Saroj, "Water–Energy–Pollution Nexus for Growing Cities," *Urban Climate*, vol. 10, no. 5, 2014.

climate change,[195] agriculture (or food),[196] population,[197] and similar other issues that together contribute a system, a complex, or simply, a nexus. The recently popular nexus approach has been a less studied or ignored subject until 1980s.[198]

There is no commonly agreed definition for the nexus. Water-energy-food nexus, according to Keskinen et al., can be seen as an "analytical tool" for academic research, a "governance framework" closely related to water governance issues discussed above, and an "emerging discourse."[199] The discourse perspective is on value and normative levels, asking questions of "what we must and should do? What we want to do?" The governance perspective is on normative and pragmatic

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[195] M. Welsch et al., "Adding Value with CLEWS – Modelling the Energy System and its Interdependencies for Mauritius," *Applied Energy*, vol. 113, 2014; Michael Beck & Rodrigo Villarroel Walker, "On Water Security, Sustainability, and the Water-Food-Energy-Climate Nexus," *Frontiers of Environmental Science & Engineering*, vol. 7, no. 5, 2013.

[196] For examples, see: M. Bazilian, et al., "Considering the Energy, Water, and Food Nexus: Towards an Integrated Modelling Approach," *Energy Policy*, vol. 39, no. 12, 2011; U. Lele, M. Klousia-Marquis & S. Goswami, "Good Governance for Food, Water and Energy Security," in *At the Confluence - Selection from the 2012 World Water Week in Stockholm*., 2013; Richard Lawford et al., "Basin perspectives on the Water–Energy–Food Security Nexus," *Current Opinion in Environmental Sustainability*, vol. 5, no. 6, 2013; Heather Cooley et al., "Global Water Governance in the Twenty-First Century," in Peter Gleick et al. *The World's Water*, 2014, p.5; Marko Keskinen et al., "The Water-Energy-Food Nexus and the Transboundary Context: Insights from Large Asian Rivers," *Water*, vol. 8, no. 5, 2016; Mike Muller, "The 'Nexus' As a Step Back towards a More Coherent Water Resource Management Paradigm," *Water Alternatives*, vol. 8, no. 1, 2015; John Finley & James Seiber, "The Nexus of Food, Energy, and Water," *Journal of Agricultural and Food Chemistry*, vol. 62, 2014; Alex Smajgl, John Ward & Lucie Pluschke, "The Water–Food–Energy Nexus – Realising a New Paradigm," *Journal of Hydrology*, vol. 533, 2016.

[197] Ji Chen, Haiyun Shi, Bellie Sivakumar & M. Peart, "Population, water, food, energy and dams," *Renewable and Sustainable Energy Reviews*, vol. 56, 2016.

[198] Heather Cooley et al., "Global Water Governance in the Twenty-First Century," in Peter Gleick et al. *The World's Water*, 2014, p.5; Rebecca Dodder, "A Review of Water Use in the U.S. Electric Power Sector: Insights from Systems-Level Perspectives," *Current Opinion in Chemical Engineering*, vol. 5, 2014, p.7; Tony Allan, Martin Keulertz & Eckart Woertz, "The Water–Food–Energy Nexus: An Introduction to Nexus Concepts and Some Conceptual and Operational Problems," *International Journal of Water Resources Development*, vol. 31, no. 3, 2015, p.309.

[199] Marko Keskinen et al., "The Water-Energy-Food Nexus and the Transboundary Context: Insights from Large Asian Rivers," *Water*, vol. 8, no. 5, 2016. The authors completed a comparative analysis of Central Asia, South Asia, and Southeast Asia (the Mekong) from a water-energy-food nexus perspective.

levels. The former is the subject matter of international law and politics; while the latter is the area of study of engineering, hydrology, forestry, agriculture, etc. Finally, the analytical approach perspective relies on pragmatic and empirical levels, the latter being the area of fundamental sciences such as physics, biology and sociology.[200] Keskinen et al. focus on transboundary water-energy-food nexus and its implementation. The nexus as an approach of governance should, according to authors, rely on "multisectoral" and "multistakeholder processes" on multistate or regional levels.[201]

Muller reminds that the water-energy-food nexus is nothing new and was on the agenda of global community since 1970s. The nexus gained prominence during the United Nations Conference on Environment and Development in Rio de Janeiro in 1992 with the debates on "development versus environment." However, the developed world has ignored the outcome of the 1992 Rio Conference, Agenda 21, and embraced another approach, the "Dublin IWRM approach" as coined by the author, which described water as an "economic good" while ignoring its "social and cultural dimensions."[202] Today, as this approach did not solve the problems, the dominant paradigm is returning closer to the outcome of the 1977 United Nations Conference in Mar del Plata. Accordingly, water and water management issues should be addressed locally, not globally.[203] In 2000s, the nexus approach gained momentum in the academia and policy making from the necessity of going beyond

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[200] Marko Keskinen et al., "The Water-Energy-Food Nexus and the Transboundary Context: Insights from Large Asian Rivers," *Water*, vol. 8, no. 5, 2016, p.4

[201] Marko Keskinen et al., "The Water-Energy-Food Nexus and the Transboundary Context: Insights from Large Asian Rivers," *Water*, vol. 8, no. 5, 2016, p.14.

[202] Mike Muller, "The 'Nexus' As a Step Back towards a More Coherent Water Resource Management Paradigm," *Water Alternatives*, vol. 8, no. 1, 2015, p.675.

[203] Mike Muller, "The 'Nexus' As a Step Back towards a More Coherent Water Resource Management Paradigm," *Water Alternatives*, vol. 8, no. 1, 2015, p.689.

the resource management discourse. Leck et al. emphasize the relationship between the IWRM and the nexus approach as well.[204]

According to Smajgl et al., the current conceptualizations of nexus are “water-centric” and a more balanced among the sectors and dynamic nexus approach is needed.[205] Among various nexuses, the water-energy nexus, one of the most commonly analyzed linkages in the literature,[206] gained prominence at the end of the century, while social science theorizing attempts in this field remained inadequate.[207] The nexus was first conceptualized by Gleick in 1994.[208] More recently, in 2012, *Ecology and Society Journal* published a special issue on water-energy

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[204] Hayley Leck, Declan Conway, Michael Bradshaw & Judith Rees, "Tracing the Water–Energy–Food Nexus: Description, Theory and Practice," *Geography Compass*, vol. 9, no. 8, 2015, p.447

[205] Alex Smajgl, John Ward & Lucie Pluschke, "The Water–Food–Energy Nexus – Realising a New Paradigm," *Journal of Hydrology*, vol. 533, 2016.

[206] See, for example: Lucy Allen, Michael Cohen, David Abelson & Bart Miller, "Fossil Fuels and Water Quality," in Peter Gleick et al. *The World's Water*, 2014; Frank Ackerman & Jeremy Fisher, "Is There a Water-Energy Nexus in Electricity Generation? Long-term Scenarios for the Western United States," *Energy Policy*, vol. 59, 2013; Asit Biswas, "Integrated Water Resources Management: Is It Working?," *International Journal of Water Resources Development*, vol. 24, no. 1, 2008; Karen Hussey & Jamie Pittock, "The Energy–Water Nexus: Managing the Links between Energy and Water for a Sustainable Future," *Ecology and Society*, vol. 17, no. 1, 2012; Benjamin Sovacool & Kelly Sovacool, "Identifying Future Electricity–Water Tradeoffs in the United States," *Energy Policy*, vol. 37, no. 7, 2009; Lu Liu et al., "Water Demands for Electricity Generation in the U.S.: Modeling Different Scenarios for the Water–Energy Nexus," *Technological Forecasting and Social Change*, vol. 94, 2015; Brendan Walsh, Sean Murray & D.T.J. O’Sullivan, "The Water Energy Nexus, An ISO50001 Water Case Study and the Need for a Water Value System," *Water Resources and Industry*, vol. 10, 2015; Arjen Hoekstra & Mesfin Mekonnen, "The Water Footprint of Humanity," *Proceedings of the National Academy of Sciences of the United States of America*, vol. 109, no. 9, 2012; Robert Holland et al., "Global Impacts of Energy Demand on the Freshwater Resources of Nations," *Proceedings of the National Academy of Sciences of the United States of America*, 2015; Afreen Siddiqi & Laura Anadon, "The Water–Energy Nexus in Middle East and North Africa," *Energy Policy*, vol. 39, no. 8, 2011.

[207] Tony Allan, Martin Keulertz & Eckart Woertz, "The Water–Food–Energy Nexus: An Introduction to Nexus Concepts and Some Conceptual and Operational Problems," *International Journal of Water Resources Development*, vol. 31, no. 3, 2015, p.309.

[208] Rebecca Dodder, "A Review of Water Use in the U.S. Electric Power Sector: Insights from Systems-Level Perspectives," *Current Opinion in Chemical Engineering*, vol. 5, 2014, p.7.

nexus. This publication was a result of a series of workshops supported by the European Cooperation in Science and Technology in 2008.

2.5.1. The water-energy nexus and water footprint

The water-energy nexus simply summarizes the natural and technical phenomenon on system-level[209] that water and energy relies each other. This reliance is asymmetrical: the energy needed to capture,[210] pump, transfer and treat water is relatively less significant than the water used for mining, hydraulic fracturing,[211] refining oil and gas, power plant cooling and hydroelectricity generation.[212] There are further interdependencies: agriculture is a significant consumer of water, and it withdraws about 70 percent of freshwater globally. Similarly, energy is a must for agricultural production, and global food prices are dependent on the price level of energy.[213]

The literature distinguishes between blue, green and gray water. The former is the water available in water bodies, such as lakes, seas and rivers. Blue water is the water provided by the rainfall and held by the soil, and gray water indicates water pollution. While the blue water can be priced, the green is not eligible for pricing. Blue water is used in the production processes of nearly all commodities. On the other hand, food and other agricultural production highly depend on green water. When blue water is used in agricultural production, such as cotton cultivation, "it

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[209] Rebecca Dodder, "A Review of Water Use in the U.S. Electric Power Sector: Insights from Systems-Level Perspectives," *Current Opinion in Chemical Engineering*, vol. 5, 2014, p.7.

[210] Heather Cooley et al., "Global Water Governance in the Twenty-First Century," in Peter Gleick et al. *The World's Water*, 2014, p.6.

[211] Heather Cooley & Kristina Donnelly, "Hydraulic Fracturing and Water Resources," in Peter Gleick, et al. *The World's Water*, 2014.

[212] Karen Hussey & Jamie Pittock, "The Energy–Water Nexus: Managing the Links between Energy and Water for a Sustainable Future," *Ecology and Society*, vol. 17, no. 1, 2012.

[213] Heather Cooley et al., "Global Water Governance in the Twenty-First Century," in Peter Gleick et al. *The World's Water*, 2014, p.5.

competes with other water users in industry."[214] Nearly 80 percent of the evaporation and transpiration as a consequence of agricultural production comes from green water, and the remaining from the blue water.[215] Globally, the 20 percent of the blue water agriculture (irrigated agriculture) accounts for 40 percent of the world food production.[216] While most of the world depends on green water for agriculture, arid areas such as Middle East and Central Asia depend mostly on blue water. A third category is gray water, which indicates the pollution level of freshwater resources. The gray water is described as the amount of freshwater required to eliminate the pollution in freshwater.[217]

Another distinction regarding the water-energy nexus is the "withdrawal" or "use" and "consumption" of water. Water withdrawal refers to "any water diverted from a surface or groundwater source."[218] According to this definition, only blue water can be subject to withdrawal. Water consumption or consumed water is the water that does not return to its source, because of evaporation, transpiration by plants, and incorporation into products, transfer to a different catchment area or to the sea,

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[214] Tony Allan, Martin Keulertz & Eckart Woertz, "The Water–Food–Energy Nexus: An Introduction to Nexus Concepts and Some Conceptual and Operational Problems," *International Journal of Water Resources Development*, vol. 31, no. 3, 2015, p.305.

[215] David Molden, *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture* (London: Earthscan, International Water Management Institute & Comprehensive Assessment of Water Management in Agriculture (Program), 2007), pp.5-7.

[216] U. Lele, M. Klousia-Marquis & S. Goswami, "Good Governance for Food, Water and Energy Security," in *At the Confluence - Selection from the 2012 World Water Week in Stockholm*., 2013, p.51.

[217] Arjen Hoekstra & Mesfin Mekonnen, "The Water Footprint of Humanity," *Proceedings of the National Academy of Sciences of the United States of America*, vol. 109, no. 9, 2012, p.3232.

[218] Lu Liu et al., "Water Demands for Electricity Generation in the U.S.: Modeling Different Scenarios for the Water–Energy Nexus," *Technological Forecasting and Social Change*, vol. 94, 2015, p.319; US Department of Energy, *The Water-Energy Nexus: Challenges and Opportunities*, 2014, available at: http://energy.gov/sites/prod/files/2014/07/f17/Water%20Energy%20Nexus%20Full%20Report%20July%202014.pdf, p.1; Rebecca Dodder, "A Review of Water Use in the U.S. Electric Power Sector: Insights from Systems-Level Perspectives," *Current Opinion in Chemical Engineering*, vol. 5, 2014, p.8.

or withhold and release in different periods of the season.[219] Both blue and green water can be consumed.[220] It simply means the "loss of water from the available ground-surface water body in a catchment area."[221]

Industry is an important water user. The main area of use of water in industrial sector is "heat transfer" in the form of heating or cooling, producing steam, washing of the products and the factories, controlling air pollution, or incorporation into products.[222] Power plants, especially the thermoelectric plants, use vast amounts of water for cooling systems, for producing steam to drive turbines and to operate "environmental control systems."[223] Some of the power plants built in the mid-twentieth century to 1970s use a technology called "once-through" or "open-loop" cooling technology, which withdraws water from the source and return it to the source at a higher temperature after the cooling process. Recent systems depend on "recirculating" cooling, which use the same water several times for cooling. During this process, evaporative consumption is higher, while water withdrawal is less in comparison to once-through systems. Air cooled "dry cooling" systems are also used, but more recently, hybrid system installations as a combination of dry cooling

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[219] Arjen Hoekstra, Ashok Chapagain, Maite Aldaya & Mesfin Mekonnen, *The Water Footprint Assessment Manual: Setting the Global Standard* (London, Washington DC: Earthscan, 2011), p.24.

[220] US Department of Energy, *The Water-Energy Nexus: Challenges and Opportunities*, 2014, available at: http://energy.gov/sites/prod/files/2014/07/f17/Water%20Energy%20Nexus%20Full%20Report%20July%202014.pdf, p.1.

[221] Arjen Hoekstra, Ashok Chapagain, Maite Aldaya & Mesfin Mekonnen, *The Water Footprint Assessment Manual: Setting the Global Standard* (London, Washington DC: Earthscan, 2011), p.2.

[222] Colin Green, *Handbook of Water Economics: Principles and Practice* (W.Sussex: John Wiley & Sons, 2003), p.219.

[223] Rebecca Dodder, "A Review of Water Use in the U.S. Electric Power Sector: Insights from Systems-Level Perspectives," *Current Opinion in Chemical Engineering*, vol. 5, 2014, p.8.

and recirculation has become more popular.[224] With regards to renewable power, such as hydroelectricity, consumptive water use estimations vary significantly. Estimations usually ignore evaporation at huge reservoirs. In the US, the calculations range from 0 to 18,000 gallons of water per MWh of hydroelectricity.[225]

"Water footprint" is an approach for measuring the amount of water consumed while completing a process. This measurement includes fresh surface water withdrawals (blue water); rainwater intake (green water); and the degree of water pollution (gray water) during the processes of industrial and agricultural production or domestic use. Water footprint includes both direct and indirect uses of consumers and producers.[226] There are two basic methods for estimating the water footprint. The first is the volumetric approach,[227] and the second is a "life cycle assessment." While the former is based on "water management," the latter focuses on products. The volumetric approach encompasses blue, green and gray water, and the life cycle assessment includes blue water only. Vanham found that important nexus studies ignore some crucial water users such as recreation and tourism, tree biomass for energy, etc.[228]

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[224] Rebecca Dodder, "A Review of Water Use in the U.S. Electric Power Sector: Insights from Systems-Level Perspectives," *Current Opinion in Chemical Engineering*, vol. 5, 2014, p.8.

[225] Rebecca Dodder, "A Review of Water Use in the U.S. Electric Power Sector: Insights from Systems-Level Perspectives," *Current Opinion in Chemical Engineering*, vol. 5, 2014, p.11.

[226] Arjen Hoekstra, Ashok Chapagain, Maite Aldaya & Mesfin Mekonnen, *The Water Footprint Assessment Manual: Setting the Global Standard* (London, Washington DC: Earthscan, 2011), p.2.

[227] In this approach, water footprint is calculated as water volume per product or per a period of time. See: Arjen Hoekstra, Ashok Chapagain, Maite Aldaya & Mesfin Mekonnen, *The Water Footprint Assessment Manual: Setting the Global Standard* (London, Washington DC: Earthscan, 2011), p.23.

[228] D. Vanham, "Does the Water Footprint Concept Provide Relevant Information to Address the Water–Food–Energy–Ecosystem Nexus?," *Ecosystem Services*, vol. 17, 2016.

On the global scale, agricultural production in general has the highest water footprint (92 percent), while industry and domestic use accounts for 4.4 and 3.6 percent.[229] About 24 percent of domestic and industrial use has a direct relation with energy sector. Globally, the electricity sector accounts for 6.5 cubic kilometers of freshwater consumption per year; while the petroleum and natural gas sectors consume 1.6 and 0.3 cubic kilometers, respectively.[230] One should also bear in mind that bio-energy crops consume water that is related to energy.[231] The International Energy Agency estimates that between 2010 and 2035, an 85 percent increase in freshwater consumption is likely to occur, largely driven by the growth of biofuel demand.[232] The high amount of water used in the lifecycle of energy (oil, electricity, bio-energy) raises the issues of sustainable water and energy production, water degradation and pollution, and ecosystem damage.[233]

The water withdrawal for irrigation, domestic and industrial use has been increasing since the beginning of the twentieth century. According to estimates, agricultural

[229] Arjen Hoekstra & Mesfin Mekonnen, "The Water Footprint of Humanity," *Proceedings of the National Academy of Sciences of the United States of America*, vol. 109, no. 9, 2012, p.3233; Robert Holland et al., "Global Impacts of Energy Demand on the Freshwater Resources of Nations," *Proceedings of the National Academy of Sciences of the United States of America*, 2015, p.E6708.

[230] Robert Holland et al., "Global Impacts of Energy Demand on the Freshwater Resources of Nations," *Proceedings of the National Academy of Sciences of the United States of America*, 2015, p.E6708.

[231] May Wu, Marianne Mintz, Michael Wang & Salil Arora, *Consumptive Water Use in the Production of Bioethanol and Petroleum Gasoline*, 2008.

[232] Robert Holland et al., "Global Impacts of Energy Demand on the Freshwater Resources of Nations," *Proceedings of the National Academy of Sciences of the United States of America*, 2015, p.E6713.

[233] May Wu, Marianne Mintz, Michael Wang & Salil Arora, *Consumptive Water Use in the Production of Bioethanol and Petroleum Gasoline*, 2008, p.4.

withdrawals increased more than five-fold, while domestic and industrial withdrawals increased 18 times throughout the century.[234] Whether this trend would continue is an important subject of discussion in the nexus literature. There are serious modelling attempts to foresee the future water demand for electricity production. Using a model called "Global Change Assessment Model," some authors concluded that by the end of the century, water withdrawals for electricity production will decrease, while general water consumption will increase as a result of population and economic growth. The decrease in water withdrawal for electricity generation will be due to development in cooling technology of power plants, increased consciousness of climate change, adoption of water-saving technologies, etc.[235] These decreases would be possible under different assumptions or scenarios, such as implementing laws and regulations to reduce water use, cap on carbon emissions, or water and carbon limits.[236]

Energy is used in sourcing, treatment, and distribution of water, while water is used in energy production on various phases. The energy required to deliver one cubic meter water for human usage differs according to the source of water. The cheapest is securing water from a lake or river, having a cost of 0.37 kWh energy. Drilling for groundwater costs 0.48 kWh; treating wastewater costs between 0.62 and 0.87 kWh; reusing wastewater costs 1 to 2.5 kWh; and treating seawater requires 2.58

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[234] Evan Davies, Page Kyle & James Edmonds, "An Integrated Assessment of Global and Regional Water Demands for Electricity Generation to 2095," *Advances in Water Resources*, vol. 52, 2013, p.296.

[235] Evan Davies, Page Kyle & James Edmonds, "An Integrated Assessment of Global and Regional Water Demands for Electricity Generation to 2095," *Advances in Water Resources*, vol. 52, 2013; Lu Liu et al., "Water Demands for Electricity Generation in the U.S.: Modeling Different Scenarios for the Water–Energy Nexus," *Technological Forecasting and Social Change*, vol. 94, 2015.

[236] Frank Ackerman & Jeremy Fisher, "Is There a Water-Energy Nexus in Electricity Generation? Long-term Scenarios for the Western United States," *Energy Policy*, vol. 59, 2013.

up to 8.5 kWh of energy per cubic meter of water supply, according to Walsh, Murray and O'Sullivan.[237] Globally, approximately 8 percent of generated energy is used to pump, transport and treat water.[238]

Water used for energy generation is the other side of the coin. Nearly 90 percent of power generation worldwide is "water-dependent." In other words, 90 percent of electricity is produced by boiling water to create steam to feed turbines.[239] Thermal power plants, having the most significant share of world energy production, use about 40 and 50 percent of total freshwater withdrawals in Europe and the US, respectively.[240] Irrigation in the US is responsible for 37 percent of total withdrawals.[241] Globally, International Energy Agency estimates, nearly 15 percent of the total freshwater withdrawals belong to energy production, as of 2010.[242] Some suggest that internationally accepted standards, such as the ISO14046 "Environmental

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[237] Brendan Walsh, Sean Murray & D.T.J. O'Sullivan, "The Water Energy Nexus, An ISO50001 Water Case Study and the Need for a Water Value System," *Water Resources and Industry*, vol. 10, 2015, p.19.

[238] The Climate Reality Project, "A Thirst for Power: The Water-Energy Nexus," *The Climate Reality Project*, 2016, available at: https://www.climaterealityproject.org/blog/thirst-power-water-energy-nexus (accessed 10 August 2016).

[239] The Climate Reality Project, "A Thirst for Power: The Water-Energy Nexus," *The Climate Reality Project*, 2016, available at: https://www.climaterealityproject.org/blog/thirst-power-water-energy-nexus (accessed 10 August 2016).

[240] US Department of Energy, *The Water-Energy Nexus: Challenges and Opportunities*, 2014, available at: http://energy.gov/sites/prod/files/2014/07/f17/Water%20Energy%20Nexus%20Full%20Report%20July%202014.pdf, p.1; Lu Liu et al., "Water Demands for Electricity Generation in the U.S.: Modeling Different Scenarios for the Water–Energy Nexus," *Technological Forecasting and Social Change*, vol. 94, 2015, p.319; The Climate Reality Project, "A Thirst for Power: The Water-Energy Nexus," *The Climate Reality Project*, 2016, available at: https://www.climaterealityproject.org/blog/thirst-power-water-energy-nexus (accessed 10 August 2016).

[241] Lu Liu et al., "Water Demands for Electricity Generation in the U.S.: Modeling Different Scenarios for the Water–Energy Nexus," *Technological Forecasting and Social Change*, vol. 94, 2015, p.318.

[242] Brendan Walsh, Sean Murray & D.T.J. O'Sullivan, "The Water Energy Nexus, An ISO50001 Water Case Study and the Need for a Water Value System," *Water Resources and Industry*, vol. 10, 2015, p.20.

Management: Water Footprint," and management practices would increase efficiency in water management.[243]

Water is also consumed in the lifecycle of energy. In the secondary phase oil recovery, during hydraulic fracturing,[244] a high amount of water, with chemical additives and "propping agent" (e.g. sand, ceramic beads, etc.), is injected into the earth to extract more oil by creating cracks in the rocks. During this process, an amount of injected water with additives remains underground.[245] Although this amount depends on the well, in the US, the net water use (water injection minus produced water) ranges from 2 to 5.5 gal per gal of crude oil extracted.[246] Refining oil also consumes water. In the US, the amount ranges from 0.5 to 2.5 gallons of water per gallons of processed crude.[247]

2.5.2. The nexus and politics

As water professionals studying water-energy nexus and all other nexuses advise policymakers to assess water, energy and other related issues and policies as a whole, the highly technical issues such as "water footprint" and "virtual water flows" further complicate the already challenging situation of water and energy policies. Virtual water and its trade contributes to the scarcity of water and contribute to the political characteristic of water. It is also important in terms of development policies, taking into consideration that nearly 1,000 liters of water is needed to produce

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[243] Brendan Walsh, Sean Murray & D.T.J. O'Sullivan, "The Water Energy Nexus, An ISO50001 Water Case Study and the Need for a Water Value System," *Water Resources and Industry*, vol. 10, 2015, p.27.

[244] Heather Cooley & Kristina Donnelly, "Hydraulic Fracturing and Water Resources," in Peter Gleick et al. *The World's Water*, 2014.

[245] Heather Cooley & Kristina Donnelly, "Hydraulic Fracturing and Water Resources," in Peter Gleick et al. *The World's Water*, 2014, p.64.

[246] May Wu, Marianne Mintz, Michael Wang & Salil Arora, *Consumptive Water Use in the Production of Bioethanol and Petroleum Gasoline*, 2008, p.3.

[247] May Wu, Marianne Mintz, Michael Wang & Salil Arora, *Consumptive Water Use in the Production of Bioethanol and Petroleum Gasoline*, 2008, p.4.

one kilogram wheat and almost 4,800 liters of water is to be consumed for a hamburger.[248] Domestically, the largest blue water footprint per capita is in Turkmenistan, with 740 cubic meter per year per capita.[249]

Hussey and Pittock observe that energy and water policies are usually developed separately.[250] Policies to develop one sector may add pressure on the other interrelated sector, either in water- or in energy-related sectors.[251] This is especially true for developing countries. On the other hand, in some developed countries like the US, an understanding of policymaking has developed recently that treats these nexuses as a whole.[252] The energy sector in the US uses the highest amount of water. Also, the prominent international organizations such as the United Nations and the World Business Council for Sustainable Development have been well aware of the importance of the subject.[253]

Allan, Keulertz, and Woertz point to the link between the nexus and economy. Accordingly, both food and energy are "emotional" inputs for the society and the water, food and energy policies, such as taxes and subsidies, directly affect the "social

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[248] Jeroen Warner & Kai Wegerich, "Is Water Politics? Towards International Water Relations," in K. Wegerich & J. Warner, eds. *The Politics of Water: A Survey* 1st ed., 2010, p.5.

[249] Arjen Hoekstra & Mesfin Mekonnen, "The Water Footprint of Humanity," *Proceedings of the National Academy of Sciences of the United States of America*, vol. 109, no. 9, 2012, p.3234.

[250] Karen Hussey & Jamie Pittock, "The Energy–Water Nexus: Managing the Links between Energy and Water for a Sustainable Future," *Ecology and Society*, vol. 17, no. 1, 2012.

[251] Karen Hussey & Jamie Pittock, "The Energy–Water Nexus: Managing the Links between Energy and Water for a Sustainable Future," *Ecology and Society*, vol. 17, no. 1, 2012.

[252] US Department of Energy, *The Water-Energy Nexus: Challenges and Opportunities*, 2014, available at: http://energy.gov/sites/prod/files/2014/07/f17/Water%20Energy%20Nexus%20Full%20Report%20July%202014.pdf.

[253] Karen Hussey & Jamie Pittock, "The Energy–Water Nexus: Managing the Links between Energy and Water for a Sustainable Future," *Ecology and Society*, vol. 17, no. 1, 2012.

contract" between political leaders and the society.[254] Internationally, agriculture policies of rich OECD countries have a determining impact on food prices, while energy prices, especially oil prices, 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, which are often underreported.[255] Scott et al. suggest two concepts in water-energy nexus decision-making: "resource coupling" and "multi-tiered institutional arrangements." Resource coupling refers to a wide perspective for water-energy nexus, beyond "pumps and turbines," taking into account the regional and basin-scale resources of water and energy for human demands. This includes the argument that global demand for resources have impacts on local levels. Multi-tiered institutional arrangements refer to "laws, policies and organizations that operate across jurisdictional levels for the management of resources."[256] The authors suggest that institutions and decision-making practices should be integrated into the water-energy nexus.[257]

Similarities and differences between water and energy play a decisive role in water-energy nexus and policymaking. According to Walsh, Murray, and O'Sullivan, while utilizing both water and energy, people somehow cause impact on climate and environment. As national incomes grow globally, demand for energy and water tends to grow during the course of the history. Yet, the quality and quantity of both

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[254] Tony Allan, Martin Keulertz & Eckart Woertz, "The Water–Food–Energy Nexus: An Introduction to Nexus Concepts and Some Conceptual and Operational Problems," *International Journal of Water Resources Development*, vol. 31, no. 3, 2015, p.302.

[255] Tony Allan, Martin Keulertz & Eckart Woertz, "The Water–Food–Energy Nexus: An Introduction to Nexus Concepts and Some Conceptual and Operational Problems," *International Journal of Water Resources Development*, vol. 31, no. 3, 2015, pp.302-04.

[256] Christopher Scott et al., "Policy and Institutional Dimensions of the Water-Energy Nexus," *Energy Policy*, vol. 39, no. 10, 2011, p.6623.

[257] Christopher Scott et al., "Policy and Institutional Dimensions of the Water-Energy Nexus," *Energy Policy*, vol. 39, no. 10, 2011, p.6629.

vary significantly across the globe. There is a dramatic difference between the relative costs of water and energy resources. As a result, the energy business is much larger than the water business. Consequently, energy industry and business influence and are influenced by politics and policy-making. In addition, availability of energy data is higher than water data.[258] Another difference, according to Scott et al., is that energy is transferable and can travel long distances in various forms, while water is a "local or regional resource."[259] Thus, energy policies can be on global scale, while water policies remain on local, regional or basin scale.

A recent and highly significant development in the literature and policymaking is the recognition of the importance of climate change and its impacts on the global economy.[260] Emphasizing climate, land, energy, water nexus, Welsch et al. showed the importance of climate change in assessing the linkages in the subject matter. Increasing demand for hydroelectricity may further increase the importance of such a nexus.[261] The World Bank research concluded that water scarcity, together with accelerating impacts of climate change, can cause a shrinkage in national incomes up to 6 percent by 2050. This may cause mass migration and conflict around the globe. The fact that the negative impacts of water scarcity and climate change may

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[258] Brendan Walsh, Sean Murray & D.T.J. O'Sullivan, "The Water Energy Nexus, An ISO50001 Water Case Study and the Need for a Water Value System," *Water Resources and Industry*, vol. 10, 2015.

[259] Christopher Scott et al., "Policy and Institutional Dimensions of the Water-Energy Nexus," *Energy Policy*, vol. 39, no. 10, 2011, p.6629.

[260] *Energy Policy* published a special issue in 2002 devoted to politics and economics of hydroelectricity. See: Frans Koch, "Hydropower—the politics of water and energy: Introduction and overview," *Energy Policy*, vol. 30, no. 14, 2002.

[261] M. Welsch et al., "Adding Value with CLEWS – Modelling the Energy System and its Interdependencies for Mauritius," *Applied Energy*, vol. 113, 2014, pp.1443-44. See also: Sebastian Hermann, et al., "The CLEW Model – Developing an integrated tool for modelling the interrelated effects of Climate, Land use, Energy, and Water (CLEW)," in *6th Dubrovnik Conference on Sustainable Development of Energy, Water and Environment Systems - Proceedings*., 2011.

be reversed with better water and environment policies[262] increased the importance of the resource management globally.

Criticizing the nexus approach from a Foucauldian perspective, Leese and Meisch argue that the nexus approaches are dominated by the neoliberal discourse and the current understanding of the water, energy and food nexus is highly "securitized." The agenda of the nexus debates has shifted from a focus on "distributional justice" towards security of supply and economy. The authors think that the issue of sustainability is seen as an "imminent threat that legitimizes urgent action."[263]

Some studies try 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."[264] The authors think that the priorities and aims of both IWRM and nexus approach overlap to a great degree. The IWRM has been dominant since it was embraced at international platforms as a guidance for development.[265]

2.6. Conclusion

This chapter tries to analyze and explore the literature from the theoretical aspect of water and hydroelectricity along with the scholarly debates on international hydropolitics. The multidisciplinary character of the subject necessitates the scrutiny of a wide range of papers of various disciplines including, but not limited to, political geography, environmental history, hydrology, ecology, earth sciences, engineering, politics, and economics.

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[262] World Bank, *High and Dry: Climate Change, Water, and the Economy*, World Bank, 2016.

[263] Matthias Leese & Simon Meisch, "Securitising Sustainability? Questioning the 'Water, Energy and Food-Security Nexus'," *Water Alternatives*, vol. 8, no. 1, 2015, p.704.

[264] David Benson, Animesh Gain & Josselin Rouillard, "Water Governance in a Comparative Perspective: From IWRM to a 'Nexus' Approach?," *Water Alternatives*, vol. 8, no. 1, 2015, p.757.

[265] David Benson, Animesh Gain & Josselin Rouillard, "Water Governance in a Comparative Perspective: From IWRM to a 'Nexus' Approach?," *Water Alternatives*, vol. 8, no. 1, 2015.

Basically, this chapter argues that the approaches in the literature that try to connect water, scarcity, power, and conflict are influenced by a neo-Malthusian realism. These studies evaluate riparian relations within the state-centric framework of power struggle, maximization of state interest, and survival. On the other hand, some approaches focus on river basin institutions, regimes, and cooperation and have an optimistic outlook. The scholars embracing such an approach maintain the view that the application of widely-recognized river basin management principles, such as the IWRM, or the RBM, would support an optimum structure of a sustainable agriculture, water management and energy nexus. These are the reflections of the institutionalist IR studies that focus on cooperation instead of conflict, emphasizing international law, organizations and regimes.

While the critical approaches, including Marxist, constructivist, feminist, or post-structuralist perspectives, try to remain at a distance either from the state-centrism or the determinism of the traditional theories, a technical and important aspect of the literature is the nexus approach, which embraces both theoretical and practical politics and economics. This study evaluates the nexus approach from the perspective of international politics and regional trade relations arguing that the trans-boundary water development and management issues within the key river basins along with the hydroelectricity production and trade issues should be evaluated as a whole. In that respect, this study comparatively analyses water management and hydropower trade models in some key river basins from around the world to reach some generalizations. Before going into the scrutiny of the cases, the following chapter explores the relationship between water, hydroelectricity trade, and economy in some detail.

CHAPTER III

WATER AND ELECTRICITY TRADE

> Farmers have […] been described as people who lose either way: from a poor harvest or from a good harvest.
>
> Colin Green, 2003[266]

> We dammed half our world's rivers at unprecedented rates of one per hour, and at unprecedented scales of over 45,000 dams more than four storeys high.
>
> Kader Asmal, 2000[267]

3.1. Introduction

Freshwater scarcity is an important item on the agenda of global politics.[268] The issue is so serious that some scholars sought to find connections between water scarcity and global political crises. The outcomes of the 2014 and 2015 Global

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[266] Colin Green, *Handbook of Water Economics: Principles and Practice* (W.Sussex: John Wiley & Sons, 2003), p.280.

[267] World Commission on Dams, *Dams and Development: A New Framework for Decision-Making* (London and Sterling: Earthscan, 2000), p.i.

[268] See, for example: Fred Boltz, "How do we prevent today's water crisis becoming tomorrow's catastrophe?," *World Economic Forum*, 2017, available at: https://www.weforum.org/agenda/2017/03/building-freshwater-resilience-to-anticipate-and-address-water-crises/ (accessed 6 February 2018); Giulio Boccaletti, "Water for people or nature is a false choice. We need to think bigger to protect the world's water," *World Economic Forum*, 2017, available at: https://www.weforum.org/agenda/2017/07/water-for-people-or-nature-is-a-false-choice-we-need-to-think-bigger-to-protect-the-worlds-water/ (accessed 6 February 2018).

Risks Perception Survey of the World Economic Forum are indicators of this. The surveyed experts and decision makers worldwide see water crisis as a significant risk regarding the impact that it may arise.[269]

As discussed in the Seventh World Water Forum in 2015, the issue of water management was primarily understood as an issue of engineering and its social and economic aspects are usually ignored.[270] With respect to energy trade, studies on oil and gas dominate the literature.[271] On the other hand, hydropower and electricity trade across regions within the countries and across national boundaries between countries have a great impact on the bilateral hydropolitical relations. In this chapter, the nexus of water and hydroelectricity issues are evaluated with a special emphasis on economic standpoint.

3.2. Water and economy

An argument of this study is that water policies and water development projects have close relations with economy.[272] Beginning from the late nineteenth century, modern water management systems developed upon local practices[273] prioritized increasing supply of water even under lack of demand. Since the 1970s, however,

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[269] In 2014, water crisis ranked first in terms of impact and eighth in terms of likelihood, while in 2015 the impact decreased to third and the likelihood decreased to ninth rank. See: World Economic Forum, *Global Risks Report 2016*, WEF, 2016, available at: http://www3.weforum.org/docs/Media/TheGlobalRisksReport2016.pdf (accessed 4 March 2017).

[270] World Water Council, *Final Report*, World Water Forum, 2015, p.52.

[271] Kathleen Hancock & Vlado Vivoda, "International Political Economy: A Field Born of the OPEC Crisis Returns to its Energy Roots," *Energy Research & Social Science*, vol. 1, no. March, 2014, p.207; Thijs Graaf, et al., "States, Markets, and Institutions: Integrating International Political Economy and Global Energy Politics," in T.V.d. Graaf et al., eds. *The Palgrave Handbook of the International Political Economy of Energy*, 2016, p.11.

[272] Thijs Graaf, et al., "States, Markets, and Institutions: Integrating International Political Economy and Global Energy Politics," in T.V.d. Graaf et al., eds. *The Palgrave Handbook of the International Political Economy of Energy*, 2016, p.11.

[273] See: Colin Green, *Handbook of Water Economics: Principles and Practice* (W.Sussex: John Wiley & Sons, 2003), p.279.

managing the demand for water through institutions emerged as a viable policy option than taking measures for increasing supply,[274] especially under the increasing impacts of climate change and over-development of water resources in many river basins throughout the world.

3.2.1. The institutional aspect

Throughout the history, water management policies have reflected political traditions, as well as the economic and institutional infrastructures of sates. Wittfogel's institutional-anthropological analysis of water indicates that hydraulic works may not be dependent solely on geographical, technological, and economic factors.[275] Famously known as the hydraulic hypothesis, the study of Wittfogel on the "hydraulic societies" published in the 1950s created an ongoing academic debate and a specific literature since then.[276]

Wittfogel observed that some large, authoritarian, and longstanding civilizations emerged in the Orient, which he calls "hydraulic societies,"[277] had some common peculiarities that diverge from those of the Western civilizations. They were masters of construction, and able to organize vast amounts of resources and large

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[274] See, for example: Dale Whittington, Xun Wu & Claudia Sadoff, "Water Resources Management in the Nile Basin: The Economic Value of Cooperation," *Water Policy*, vol. 7, no. 3, 2005.

[275] Karl Wittfogel, *Oriental Despotism: A Comparative Study of Total Power* (New Haven and London: Yale University Press, 1957), p.161.

[276] For some examples from various decades, see: O. Spate, "The "Hydraulic Society"," *Annals of The Association of American Geographers*, vol. 49, no. 1, 1959; Tatsuo Masubuchi, "Wittfogel's Theory of Oriental Society (or Hydraulic Society) and the Development of Studies of Chinese Social and Economic History in Japan," *The Developing Economies*, vol. 4, no. 3, 1966; William Mitchell, "The Hydraulic Hypothesis: A Reappraisal'," *Current Anthropology*, vol. 14, no. 5, 1973; Donald Worster, "Hydraulic Society in California: An Ecological Interpretation," *Agricultural History*, vol. 56, no. 3, 1982; David Price, "Wittfogel's Neglected Hydraulic/Hydroagricultural Distinction," *Journal of Anthropological Research*, vol. 50, no. 2, 1994; François Molle, Peter Mollinga & Philippus Wester, "Hydraulic Bureaucracies and the Hydraulic Mission: Flows of Water, Flows of Power," *Water Alternatives*, vol. 2, no. 3, 2009.

[277] Karl Wittfogel, *Oriental Despotism: A Comparative Study of Total Power* (New Haven and London: Yale University Press, 1957), p.8.

masses into workforce. Also, they had an absolute hegemony on property, and keep religion under state control. But more importantly, all these properties originated from a single aspect: the construction and maintenance of large hydraulic systems, both productive (irrigation canals, aqueducts, reservoirs, etc.) and protective (flood control structures).[278] In his study, Wittfogel inquires in some detail the socioeconomic and institutional aspects of hydraulic societies, some of which are also included in this study. Worth noting among them are China and Egypt.

The institutional aspect of the relationship between political authority and water management became subject to further studies in the literature. Based on Wittfogel's hypothesis, Worster argued that "the modern capitalist-based irrigation societies and the ancient hydraulic power complexes" are to a considerable degree "closely parallel."[279] Molle et al. carry the discussion one step further arguing that the modern water bureaucracies since the beginning of the twentieth century have been important agents for the state power and its economic model to infiltrate into distant parts of territorial nation states.[280] Some examples of powerful governmental water administrations, also scrutinized in this study, are the US Bureau of Reclamation and the Army Corps of Engineers, or the State Hydraulic Works in Turkey.[281] The close relationship between centralized water bureaucracies and politics has occasionally became obvious in the cases similar to Turkey.[282] As Menga

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[278] Karl Wittfogel, *Oriental Despotism: A Comparative Study of Total Power* (New Haven and London: Yale University Press, 1957), p.12 and 42.

[279] Donald Worster, "Hydraulic Society in California: An Ecological Interpretation," *Agricultural History*, vol. 56, no. 3, 1982, p.506.

[280] F. Molle, P.P. Mollinga & P. Wester, "Hydraulic Bureaucracies and the Hydraulic Mission: Flows of Water, Flows of Power," *Water Alternatives*, vol. 2, no. 3, 2009, pp.329-30.

[281] F. Molle, P.P. Mollinga & P. Wester, "Hydraulic Bureaucracies and the Hydraulic Mission: Flows of Water, Flows of Power," *Water Alternatives*, vol. 2, no. 3, 2009, p.339; Hilal Elver, "Turkey's Rivers of Dispute," *Middle East Report*, vol. 254, 2010.

[282] Hilal Elver, "Turkey's Rivers of Dispute," *Middle East Report*, vol. 254, 2010, p.15.

contends, politics may be used as a tool to diffuse ideas of modernization by planning and constructing “hydraulic infrastructures.”[283]

Besides political factors, other rationales behind government involvement into water-related investments are the scale of and high financing needs for large scale investments. Until the beginning of the third millennium, about two trillion US dollars are estimated to be invested in such projects worldwide.[284] Especially in the 1990s, developing countries intensified investments in large hydraulic projects as the legitimacy of dam building in the West began to be questioned beginning from the 1970s, and nearly all economically feasible locations in the US and Europe were dammed. In this decade, of the 32-46 billion US dollars spent for the hydraulic projects *annually*, 80 percent was spent by the developing countries. Again, 80 percent of the investments in the developing world was made by the public sector.[285]

Particularly the economic and environmental histories of large economies, such as the US or China, show that large hydraulic projects, such as large irrigation networks, diversion schemes, dikes, or HPPs, often need government assistance or involvement in order to be completed. As scrutinized in this study, this led to the expansion of domestic water institutions and bureaucracies. For most of the governments of the developing economies, foreign funding from international organizations,[286] aid form donor nations, and loans or technical assistance from developed

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[283] Filippo Menga, "Hydropolis: Reinterpreting the Polis in Water Politics," *Political Geography*, vol. 60, 2017, p.102.

[284] World Commission on Dams, *Dams and Development: A New Framework for Decision-Making* (London and Sterling: Earthscan, 2000), p.11.

[285] World Commission on Dams, *Dams and Development: A New Framework for Decision-Making* (London and Sterling: Earthscan, 2000), p.11.

[286] Awojobi and Jenkins evaluate the HPP projects supported by the World Bank between 1976 and 2005. The authors examine the cost aspect of 58 dams and found that the financing of the dams are worthwhile. See: Omotola Awojobi & Glenn Jenkins, "Were the Hydro Dams Financed by the World Bank from 1976 to 2005 Worthwhile," *Energy Policy*, vol. 86, 2015.

states has also been necessary.[287] In this context, the development facet of the hydraulic works has international funding or aid aspects as well, which are, in turn, closely related to politics. The British aid for the Pergau Dam in Malaysia and the following scandal was one of the most notorious cases in the political history of international involvement in the hydraulic projects.[288] Sometimes, local opposition to large dams may undermine dam building efforts supported by the international organizations as observed in the case of the Chico river in the Philippines.[289] On the other hand, in recent years, private sector involvement in dam building efforts in some developing countries has intensified, and some countries no longer need assistance from international organizations as their access to finance enhanced. Notable examples of these countries are China and Turkey.[290]

As discussed in this section, water is the most important input for agricultural production. The increase in agricultural production is among the main drivers of economic growth, especially in the developing economies. Agriculture is a major employer with the potential of immediately reducing unemployment rates. In addition, water is the main source of hydroelectricity generation, which is usually seen as the fastest, main, and sometimes only, driver of early stage development, again, in the developing world. This is often referred to as the "hydraulic mission,"[291] and

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[287] Mark Rosegrant, "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*, 2015, p.17.

[288] Claire Provost, "The Pergau dam affair: will an aid for arms scandal ever happen again?," *The Guardian*, 2012, available at: https://www.theguardian.com/global-development/2012/dec/12/pergau-dam-affair-aid-arms-scandal (accessed 15 August 2017).

[289] World Commission on Dams, *Dams and Development: A New Framework for Decision-Making* (London and Sterling: Earthscan, 2000), p.19.

[290] Deborah Moore, John Dore & Dipak Gyawali, "The World Commission on Dams + 10: Revisiting the Large Dam Controversy," *Water Alternatives*, vol. 3, no. 2, 2010, p.9.

[291] François Molle, Peter Mollinga & Philippus Wester, "Hydraulic Bureaucracies and the Hydraulic Mission: Flows of Water, Flows of Power," *Water Alternatives*, vol. 2, no. 3, 2009.

the mission is usually fulfilled or aided by the major powers in the world, the US being the foremost, the Soviet Union, China, or the EU.[292]

The relationship between water bureaucracies, international institutions, private companies and other actors are studied thoroughly in the literature.[293] The inquiry of Molle into the unsound project and planning processes of large scale hydraulic works with the involvement of the governments and other stakeholders such as the local politicians, international development agencies and private companies is among the most comprehensive studies in this respect.[294] There are a number of reasons for poor planning, such as rent-seeking, lack of participation in planning, manipulative nature of cost-benefit and impact analyses, poverty reduction, alleviation of migration pressure towards urban centers, etc. The unsound analyses of large scale water schemes often lead to "overbuilding" in a river basin and to "basin closure," as observed in the examples of the Colorado, in the Yellow river, or in the Aral Sea catchment zones.[295] These consequences are among the major sources of the modern environmental problems in the river basins globally.

Despite these examples of institutionalized mismanagement of water resources, as discussed in the previous chapter, institutions are crucial for managing water. As political and economic decisions regarding water are taken on grand scales, institu-

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[292] J. Allan, "IWRM: The New Sanctioned Discourse?," in P.P. Mollinga, A. Dixit & K. Athukorala, eds. *Integrated Water Resources Management : Global Theory, Emerging Practice and Local Needs*, 2006, p.40.

[293] François Molle, "Why Enough Is Never Enough: The Societal Determinants of River Basin Closure," *International Journal of Water Resources Development*, vol. 24, no. 2, 2008; François Molle, Peter Mollinga & Philippus Wester, "Hydraulic Bureaucracies and the Hydraulic Mission: Flows of Water, Flows of Power," *Water Alternatives*, vol. 2, no. 3, 2009; Hilal Elver, "Turkey's Rivers of Dispute," *Middle East Report*, vol. 254, 2010.

[294] François Molle, "Why Enough Is Never Enough: The Societal Determinants of River Basin Closure," *International Journal of Water Resources Development*, vol. 24, no. 2, 2008.

[295] François Molle, "Why Enough Is Never Enough: The Societal Determinants of River Basin Closure," *International Journal of Water Resources Development*, vol. 24, no. 2, 2008, p.223.

tions in varying forms are involved in one way or another. Institutions can be competitive, such as an open market mechanism for water supply, or cooperative, such as water users' associations.[296] In this respect, management of river basins is closely related to institutions. In some forms of river basin management, political and municipal boundaries are decisive, while in other forms, the hydrological boundaries are taken into consideration. The latter has been the trend and embraced by the developed economies such as the US, a well-known early example being the Tennessee Valley Authority.[297]

The demand for water and its supply are subject to temporal and spatial variations. In parallel, the water management policies should balance this demand and supply. Therefore, the policymaker is often forced to choose between decisions either of increasing supply or decreasing excessive demand.[298] The following paragraphs discuss these policy choices.

3.2.2. Water demand and supply

Global demand for water is increasing and it seems to increase steadily in the medium-term,[299] and there are various explanations for this increase in global water demand.[300] Various sectors in the economy demand huge amounts of water and this demand leads to the consumptive use of water.[301] Furthermore, this demand may

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[296] Colin Green, *Handbook of Water Economics: Principles and Practice* (W.Sussex: John Wiley & Sons, 2003), p.129.

[297] Colin Green, *Handbook of Water Economics: Principles and Practice* (W.Sussex: John Wiley & Sons, 2003), p.130.

[298] Colin Green, *Handbook of Water Economics: Principles and Practice* (W.Sussex: John Wiley & Sons, 2003), p.203.

[299] United Nations, *The United Nations World Water Development Report*, UN Water, 2017, p.2.

[300] Veronica Strang, *The Meaning of Water* (Oxford: Berg, 2004).

[301] Ruth Meinzen-Dick & Claudia Ringler, "Water Reallocation: Drivers, Challenges, Threats, and Solutions for the Poor," *Journal of Human Development and Capabilities*, vol. 9, no. 1, 2008, p.47.

occasionally lead to competition among sectors and water users.[302] According to the Food and Agriculture Organization of the UN, agriculture withdraws 2,769, industrial sector 768 and municipal sector 464 cubic kilometers of water per year, around 2010.[303] One feature of agricultural water use is that it is mostly consumptive. In agricultural activity, water is consumed by crops through transpiration or evaporated while being transferred from the source to the point of ultimate demand. From a river basin perspective, the water consumption may only occur when water is evaporated, transpired or flows directly into the sea or a lake. In principle, urban and industrial water can be reused, although in the form of greywater.[304]

There are some catalyzers of the increase in water demand. The first is the above-mentioned population growth.[305] The second is a general improvement in the living standards.[306] Also, economic growth, increased pace of urbanization, and environmental water demand are other factors that need to be addressed in considering the increase in water demand.[307] The production characteristics of a country are also

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302 Mark Rosegrant, "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*, 2015, p.3.

303 Food and Agriculture Organization of the United Nations, *Water Withdrawal by Sector, around 2010*, Aquastat, 2016, available at: http://www.fao.org/nr/Water/aquastat/tables/WorldData-Withdrawal_eng.pdf (accessed 14 August 2017); World Commission on Dams, *Dams and Development: A New Framework for Decision-Making* (London and Sterling: Earthscan, 2000), p.5.

304 Colin Green, *Handbook of Water Economics: Principles and Practice* (W.Sussex: John Wiley & Sons, 2003), p.211.

305 World Commission on Dams, *Dams and Development: A New Framework for Decision-Making* (London and Sterling: Earthscan, 2000), p.3.

306 Richard Howitt, "Water Scarcity and the Demand for Water Markets," in K. Burnett, R. Howitt, J.A. Roumasset & C.A. Wada, eds. *Routledge Handbook of Water Economics and Institutions*, 2015, p.32. In California, it is calculated that one kilogram of wheat necessitates 1.3 cubic meters of water while one kilogram of beef requires 16 cubic meters of water. See: Colin Green, *Handbook of Water Economics: Principles and Practice* (W.Sussex: John Wiley & Sons, 2003), p.277.

307 Ruth Meinzen-Dick & Claudia Ringler, "Water Reallocation: Drivers, Challenges, Threats, and Solutions for the Poor," *Journal of Human Development and Capabilities,* vol. 9, no. 1, 2008,

decisive for water demand. If the economy of a country depends on irrigated agriculture, the water consumed per unit of gross domestic product (GDP) increases.[308] As a general trend, low income countries withdraw most of the freshwater for agricultural use. If these countries are water-scarce, and the governments attempt ambitious industrialization programs, the likelihood of experiencing water crisis is higher.[309] If these countries depend on external sources for freshwater, then the water crisis would most likely have a transboundary and political character. Examples of the latter in this study are Uzbekistan, Egypt, or to some degree, Mexico.

Although projections and scenarios may vary, from a simple Malthusian perspective, there is a consensus in the literature that the world population will continue to rise, and the demand for water would follow suit in order to feed the increasing population. Yet, there are some setbacks for the further development of global agricultural activity. For instance, a considerable share of basic nutrients, such as grain, is not produced in a sustainable manner.[310] This tends to put the global population, food security, and development in many regions under severe risk.[311] Second, as industry is the second largest consumer of world freshwater resources, the continuous growth in industrial production will likely increase water demand further if

p.47; World Commission on Dams, *Dams and Development: A New Framework for Decision-Making* (London and Sterling: Earthscan, 2000), p.4.

[308] World Commission on Dams, *Dams and Development: A New Framework for Decision-Making* (London and Sterling: Earthscan, 2000), p.4.

[309] World Commission on Dams, *Dams and Development: A New Framework for Decision-Making* (London and Sterling: Earthscan, 2000), p.6.

[310] Kyle Davis, Maria Rulli, Antonio Seveso & Paolo D'Odorico, "Increased food production and reduced water use through optimized crop distribution," *Nature Geoscience*, vol. 10, no. 12, 2017.

[311] Mark Rosegrant, "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*, 2015, pp.4-5.

there would be no significant improvements in the efficiency of water use in the near future.[312]

Managing the demand of water is an important aspect of water policies, especially under conditions of scarcity. In order to increase the efficiency of water use through the market forces, and in order to achieve the goal of sustainable water management, water pricing and water markets are recommended as policy tools by international organizations such as the World Bank[313] and the United Nations.[314] The international organizations and academicians criticize the supply-side water management policies and stress the need for water pricing for equitable access to water.[315] Furthermore, water pricing has also an impact of giving the water user the signal that the water is scarce and the user should use it cautiously.[316] For this to be achieved, a strong political will is a prerequisite.[317] There are examples of such a policy in

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[312] Richard Howitt, "Water Scarcity and the Demand for Water Markets," in K. Burnett, R. Howitt, J.A. Roumasset & C.A. Wada, eds. *Routledge Handbook of Water Economics and Institutions*, 2015, p.38.

[313] Sittidaj Pongkijvorasin & James Roumasset, "Optimal Conjunctive Water Use over Space and Time," in K. Burnett, R. Howitt, J.A. Roumasset & C.A. Wada, eds. *Routledge Handbook of Water Economics and Institutions*, 2015, p.61; World Water Council, *Final Report*, World Water Forum, 2015, p.52.

[314] Olcay Ünver & Rajiv Gupta, "Water Pricing: Issues and Options in Turkey," *International Journal of Water Resources Development*, vol. 19, no. 2, 2003, pp.312-13.

[315] V. Kanakoudis & S. Tsitsifli, "Socially fair domestic water pricing: who is going to pay for the non-revenue water?," *Desalination and Water Treatment*, vol. 57, no. 25, 2016.

[316] Ariel Dina & Yacov Tsur, "Water Scarcity and Water Institutions," in K. Burnett, R. Howitt, J.A. Roumasset & C.A. Wada, eds. *Routledge Handbook of Water Economics and Institutions*, 2015

[317] World Water Council, *Final Report*, World Water Forum, 2015, p.52; Olcay Ünver & Rajiv Gupta, "Water Pricing: Issues and Options in Turkey," *International Journal of Water Resources Development*, vol. 19, no. 2, 2003.

developed economies, as in the cases of the US,[318] Australia, Chile, Spain, or Israel.[319] On the other hand, in many developing countries, the applicability of this policy is contentious.

As suggested by Easter et al., both formal and informal water markets are options for effectively allocating scarce water resources in a region, both within and among the sectors.[320] By definition, formal water markets are markets where the quantity and share of the water that is subject to trade is set formally. In informal markets, the amount of water sold is not measured, but water is allocated for a certain period of time for the buyers.[321] According to the authors, water markets are functional only if water is scarce.[322] In some regions of the world, the amount of water varies significantly depending on the season of the year or depending on annual precipitation. As climate change increases the variability in water supply, some believe that water pricing may also be beneficial for addressing such kind of specific supply

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[318] Ellen Hanak, "A California Postcard: Lessons for a Maturing Water Market," in K. Burnett, R. Howitt, J.A. Roumasset & C.A. Wada, eds. *Routledge Handbook of Water Economics and Institutions*, 2015.

[319] For some insights on the application of water pricing in developing countries, see: Chris Hunt, "Transposing of Water Policies from Developed to Developing Countries: The Case of User Pays," *Water International*, vol. 24, no. 4, 1999.

[320] William Easter, Mark Rosegrant & Ariel Dinar, "Formal And Informal Markets For Water," *World Bank Research Observer*, 2012.

[321] William Easter, Mark Rosegrant & Ariel Dinar, "Formal And Informal Markets For Water," *World Bank Research Observer*, 2012, p.107.

[322] William Easter, Mark Rosegrant & Ariel Dinar, "Formal And Informal Markets For Water," *World Bank Research Observer*, 2012, p.105.

issues, such as occasional droughts[323] exacerbated by the adverse impacts of climate change.[324]

Besides water pricing, managing water demand is also possible through non-price policies, such as providing real-time consumption information to water consumers,[325] or implementing bans on some non-necessary water uses such as garden watering or car washing. These measures may be effective as evidenced during the 1976 California drought when "voluntary constraints" reduced water demand by about one quarter. But sometimes their efficiency decreases when communication problems occur in the implementation of such policy measures.[326]

On the other hand, while demand management policies increase the efficiency of water use by altering "the patterns of flows and stocks within the catchment," they do not necessarily save water, and are classified as "dry" or "paper" water savings, as stated above. Thus, for example, if concrete irrigation canals replace the earthen ditches to reduce infiltration, this is an example of dry saving as the infiltrated water recharges the groundwater reservoirs and there is no "net" saving. "Wet" savings are possible through reduced water pollution to enable its reuse, through reallocation of it "to higher valued uses," and through an increase in output "per unit of

[323] Ellen Hanak, "A California Postcard: Lessons for a Maturing Water Market," in K. Burnett, R. Howitt, J.A. Roumasset & C.A. Wada, eds. *Routledge Handbook of Water Economics and Institutions*, 2015, p.270.

[324] Bonnie Colby, George Frisvold & Matthew Mealy, "Managing Climate Risks through Water Trading," in K. Burnett, R. Howitt, J.A. Roumasset & C.A. Wada, eds. *Routledge Handbook of Water Economics and Institutions*, 2015, pp.236-37.

[325] John Lynha & Nori Tarui, "Real-Time Information and Consumption: What Can Water Demand Programs Learn from Electricity Demand Programs? ," in K. Burnett, R. Howitt, J.A. Roumasset & C.A. Wada, eds. *Routledge Handbook of Water Economics and Institutions*, 2015.

[326] Colin Green, *Handbook of Water Economics: Principles and Practice* (W.Sussex: John Wiley & Sons, 2003), p.213.

water that is lost through evaporation, transpiration or to a sink," such as to a sea or a lake.[327]

As demand for water increases, water is increasingly becoming a scarce resource.[328] There are some factors that further exacerbate this scarcity. The first is the negative impacts of the climate change. As Howitt observes, climate change already impacted the water situation in the southern hemisphere. The second is the overuse of surface freshwater by agricultural activity, especially in some arid regions of the world.[329] Supplying water to large fields is another dimension of the issue. As stated above, water lost in the irrigation networks increases the stress on water supply. The greater the irrigated area, the higher is the amount of water that is lost during conveyance.[330] The third is the reduction and salinization of groundwater.[331]

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[327] Colin Green, *Handbook of Water Economics: Principles and Practice* (W.Sussex: John Wiley & Sons, 2003), pp.211-12.

[328] The scarcity of water is a contested issue in the literature. See, as an example: Frank Rijsberman, "Water Scarcity: Fact or Fiction?," *Agricultural Water Management*, vol. 80, no. 1-3, 2006; Murat Arsel & Max Spoor, "Follow the Water," in M. Arsel & M. Spoor, eds. *Water, environmental security and sustainable rural development: conflict and cooperation in Central Eurasia*, 2010, p.9. See also the previous chapter in this study.

[329] Richard Howitt, "Water Scarcity and the Demand for Water Markets," in K. Burnett, R. Howitt, J.A. Roumasset & C.A. Wada, eds. *Routledge Handbook of Water Economics and Institutions*, 2015, pp.31-32.

[330] Ujjayant Chakravorty, Eithan Hochman, Chieko Umetsu & David Zilberman, "Water allocation under distribution losses: Comparing alternative institutions," *Journal of Economic Dynamics and Control*, vol. 33, no. 2, 2009; Ujayant Chakravort & Yazhen Gong, "Water Allocation under Distribution Losses: A Perspective," in K. Burnett, R. Howitt, J.A. Roumasset & C.A. Wada, eds. *Routledge Handbook of Water Economics and Institutions*, 2015.

[331] Richard Howitt, "Water Scarcity and the Demand for Water Markets," in K. Burnett, R. Howitt, J.A. Roumasset & C.A. Wada, eds. *Routledge Handbook of Water Economics and Institutions*, 2015, pp.31-32.

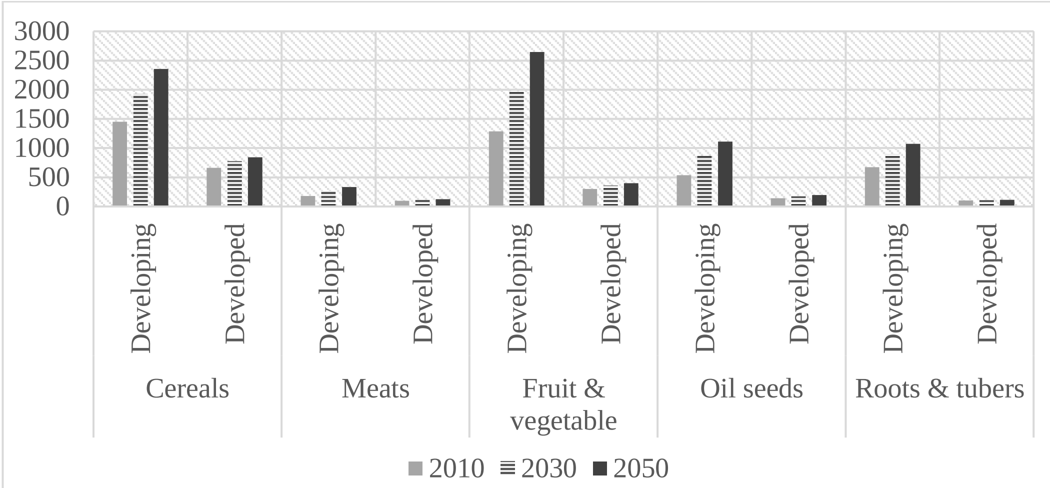

Figure 3.1. Demand projections for agricultural products[332]

Water scarcity has some economic aspects as well. Global scarcity of water would reduce the level and the pace of growth of agricultural products, leading to food price hikes.[333] According to the projections of the "international model for policy analysis of agricultural commodities and trade (IMPACT)," developed by the International Food Policy Research Institute, agricultural product demand will increase in the next 10 to 30 years, and the demand will increase in the developing world to a significant degree. By the year 2050, cereal, meat, fruit, vegetable, oil seed, pulses, roots and tubers demand will increase 1.6 to 2.1 times the 2010 levels in the developing economies. These projections are produced without taking into

[332] International Food Policy Research Institute, IMPACT Projections of Food Production, Consumption, and Hunger to 2050, With and Without Climate Change: Extended Country-level Results for 2017, IFPRI, 2017, available at: 10.7910/DVN/R9H6QI (accessed 14 August 2017).

[333] Mark Rosegrant, "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*, 2015, p.6.

consideration the negative impacts of the climate change. If the impacts of the climate change are considered, the demand would be slightly lower (Figure 3.1).[334] The irrigation water, on the other hand, is estimated to be reduced significantly in many regions of the world, especially in Europe and Central Asia.[335]

In theory, water services may be supplied in three ways, which are "common property bodies," private companies, and municipalities. The former is a method in which the users of water provide necessary labor for water delivery services. This was a common method in agricultural water services. On the other hand, the latter is the preferred method globally, namely the municipalities are usually responsible for water delivery services, especially for domestic and industrial uses.[336]

In order to secure a steady supply of water, storage is a common preference.[337] Other methods of increasing the supply are water capture and "conveying it to the point of use." In the former method, the water runoff or the rainwater can be collected in cisterns or other storages.[338] The method known as rainwater harvesting is used in South America for agricultural purposes.[339] From an economic perspective,

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[334] International Food Policy Research Institute, IMPACT Projections of Food Production, Consumption, and Hunger to 2050, With and Without Climate Change: Extended Country-level Results for 2017, IFPRI, 2017, available at: 10.7910/DVN/R9H6QI (accessed 14 August 2017).

[335] Mark Rosegrant, "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*, 2015, p.9.

[336] Colin Green, *Handbook of Water Economics: Principles and Practice* (W.Sussex: John Wiley & Sons, 2003), pp.131-36.

[337] Increasing reservoir capacity is counted among the "hard" solution for increasing water supply, while increasing water use efficiency or reducing per capita domestic water use is labelled among the "soft" solutions for water supply. See: Kyle Davis, Maria Rulli, Antonio Seveso & Paolo D'Odorico, "Increased food production and reduced water use through optimized crop distribution," *Nature Geoscience*, vol. 10, no. 12, 2017, p.919.

[338] Colin Green, *Handbook of Water Economics: Principles and Practice* (W.Sussex: John Wiley & Sons, 2003), p.204.

[339] World Commission on Dams, *Dams and Development: A New Framework for Decision-Making* (London and Sterling: Earthscan, 2000), pp.144-45.

the amount of water storage is a critical question that needs to be addressed by the policymakers. Larger storages such as great reservoirs provide advantages of economies of scale, evaporation tends to be less in comparison to building and using several smaller storages. Yet, as discussed in the following section, large dams are subject to controversy.[340]

As a consequence of increased demand and limited supply, an issue discussed in the literature and policy circles has been the possibility for inter-sectoral reallocation of water, principally from the agricultural sector to the household use. It is estimated that industrial and domestic water demand will increase faster than the agricultural water demand in the future.[341] It is calculated that "returns to irrigation per unit water use are generally low" in comparison to industrial and domestic sectors.[342] As Meinzen-Dick and Ringler summarize, the allocation of water can be achieved through administrative measures, through market forces, or through collective negotiation. Among the most famous examples of such kind of allocation is a project in the US West, as discussed further in this study.[343]

The consequence of water allocation from agriculture to non-agricultural sectors would likely be a shortage in irrigation water. This would hit the arid regions of the world most, such as Central Asia, Northeast Africa, or West America, if managed

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[340] Colin Green, *Handbook of Water Economics: Principles and Practice* (W.Sussex: John Wiley & Sons, 2003), p.210.

[341] Ruth Meinzen-Dick & Claudia Ringler, "Water Reallocation: Drivers, Challenges, Threats, and Solutions for the Poor," *Journal of Human Development and Capabilities*, vol. 9, no. 1, 2008, pp.48-49.

[342] Ruth Meinzen-Dick & Claudia Ringler, "Water Reallocation: Drivers, Challenges, Threats, and Solutions for the Poor," *Journal of Human Development and Capabilities*, vol. 9, no. 1, 2008, p.50.

[343] Ruth Meinzen-Dick & Claudia Ringler, "Water Reallocation: Drivers, Challenges, Threats, and Solutions for the Poor," *Journal of Human Development and Capabilities*, vol. 9, no. 1, 2008, pp.50-53.

poorly.[344] Food production would decline and the prices for food would increase. This may have a major impact on the poor in the developing countries.[345] In a study in 1999, Rosegrant and Ringler estimated that the average price of rice would increase by 68 percent between 1993 and 2020, the price of wheat by 50 percent, maize 31 percent, and other grains by about 40 percent. These may trigger a rise in inflation and distort the macroeconomic balances in developing economies.[346]

3.2.3. Water trade

Under these circumstances of water supply and demand, virtual water trade is becoming highly important.[347] Virtual water flows occur among countries when a commodity, during the production process of which a certain amount of water is consumed, is subject to international trade.[348] According to Hoekstra and Mekonnen, between 1996 and 2005, trade-related international virtual water flows were 68 percent green, 13 percent blue and 19 percent gray. The majority of the virtual water flows (76 percent) belong to the international trade of crops and derived crops. The top seven virtual blue water exporters are the US, Pakistan, India, Australia,

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[344] Mark Rosegrant & Claudia Ringler, *Impact on Food Security and Rural Development of Reallocating Water from Agriculture*, International Food Policy Research Institute, 1999, p.21.

[345] Colin Green, *Handbook of Water Economics: Principles and Practice* (W.Sussex: John Wiley & Sons, 2003), p.284 ; Ruth Meinzen-Dick & Claudia Ringler, "Water Reallocation: Drivers, Challenges, Threats, and Solutions for the Poor," *Journal of Human Development and Capabilities*, vol. 9, no. 1, 2008, p.58.

[346] Mark Rosegrant & Claudia Ringler, *Impact on Food Security and Rural Development of Reallocating Water from Agriculture*, International Food Policy Research Institute, 1999, p.31.

[347] Waterstat, "Water footprint statistics (WaterStat)," *Water Footprint Network*, 2016, available at: http://waterfootprint.org/en/resources/water-footprint-statistics/ (accessed 6 September 2016).

[348] A. Hoekstra & P. Hung, *Virtual Water Trade: A Quantification of Virtual Water Flows between Nations in Relation to International Crop Trade*, IHE Delft, 2002, available at: http://www.waterfootprint.org/media/downloads/Report12.pdf (accessed 6 February 2018), p.7.

Uzbekistan, China and Turkey, accounting for 49 percent of global virtual blue water exports. The majority of international virtual water flows belong to industrial crops i.e. cotton, soybean, oil palm, etc., with more than half belonging to cotton.[349]

For the individual countries, especially for those that suffer from water scarcity, virtual water trade may be a viable option for coping with the lack of sufficient agricultural water.[350] On the other hand, as food security is regarded as a strategic issue for most of the nation states, food self-sufficiency and domestic agricultural production is usually prioritized. As a result, some agricultural products are produced at higher costs than their costs elsewhere in the world. This inefficiency deteriorates the situation of global water supply.[351]

Despite this, there is a huge volume of virtual water trade taking place in the international markets through agricultural products trade. According to the FAO data, as of 2013, the total value of agricultural products trade reached about 2.83 trillion US dollars (Figure 3.2). In recent years, the agricultural products trade declined during the 2008-2010 global economic crisis, but as of 2011, the trade recovered to its pre-crisis levels. According to some accounts, the presence of the virtual water trade explains the lack of armed conflict caused by the water scarcity.[352] Yet, armed conflict is only one type of conflict that may be observed between nations, and the lack of armed conflict does not mean the lack of conflict at all.[353]

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[349] Arjen Hoekstra & Mesfin Mekonnen, "The Water Footprint of Humanity," *Proceedings of the National Academy of Sciences of the United States of America*, vol. 109, no. 9, 2012, pp.3233-34.

[350] A. K., A. Hoekstra & H. Savenije, "Water Saving Through International Trade of Agricultural Products," *Hydrology and Earth System Sciences Discussions*, vol. 10, no. 3, 2006.

[351] Richard Howitt, "Water Scarcity and the Demand for Water Markets," in K. Burnett, R. Howitt, J.A. Roumasset & C.A. Wada, eds. *Routledge Handbook of Water Economics and Institutions*, 2015, p.33.

[352] Mark Zeitoun & J. Allan, "Applying Hegemony and Power Theory to Transboundary Water Analysis," *Water Policy*, vol. 10, no. Supplement 2, 2008, p.5.

[353] Mark Zeitoun & J. Allan, "Applying Hegemony and Power Theory to Transboundary Water Analysis," *Water Policy*, vol. 10, no. Supplement 2, 2008, p.6.

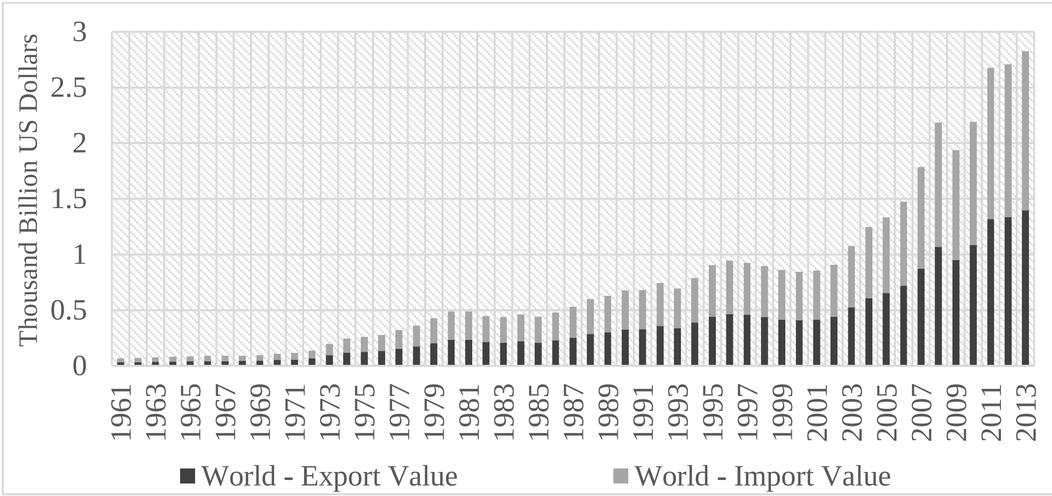

Figure 3.2. Total trade value of global agricultural products[354]

According to a research conducted by MacDonald et al., about 20 percent of cropland area in the world and the same share of water is used for agricultural products trade by the early 2010s. In terms of value, most of the agricultural exports and imports are made within the unions or trade unions such as the EU and the NAFTA.[355] Long-distance exchanges play a major role in global agricultural products trade. The trade between the US and China is a major example. The US uses about 6 percent of its total cropland for products being exported to China. China also imports considerable amounts of food (particularly soybean) from Brazil and Argentina.[356] MacDonald et al. calculated the total amount of water included in the

[354] Food and Agriculture Organization of the United Nations, "Crops and Livestock Products," *FAOSTAT*, 2017 (Last updated: 9 February 2017), available at: http://www.fao.org/faostat/en/#data/TP (accessed 16 August 2017).

[355] Graham MacDonald, et al., "Rethinking Agricultural Trade Relationships in an Era of Globalization," *BioScience*, vol. 65, no. 3, 2015, p.278.

[356] Graham MacDonald, et al., "Rethinking Agricultural Trade Relationships in an Era of Globalization," *BioScience*, vol. 65, no. 3, 2015, p.278.

16 major traded crops that constitute 85 percent of total calories traded. Accordingly, annually 810 cubic kilometers of water is embodied in the traded crops, about 65 cubic kilometers of which is irrigation water (blue water) and 745 cubic kilometers rainwater. Among the major exporters, the US uses the highest amount of blue water.[357]

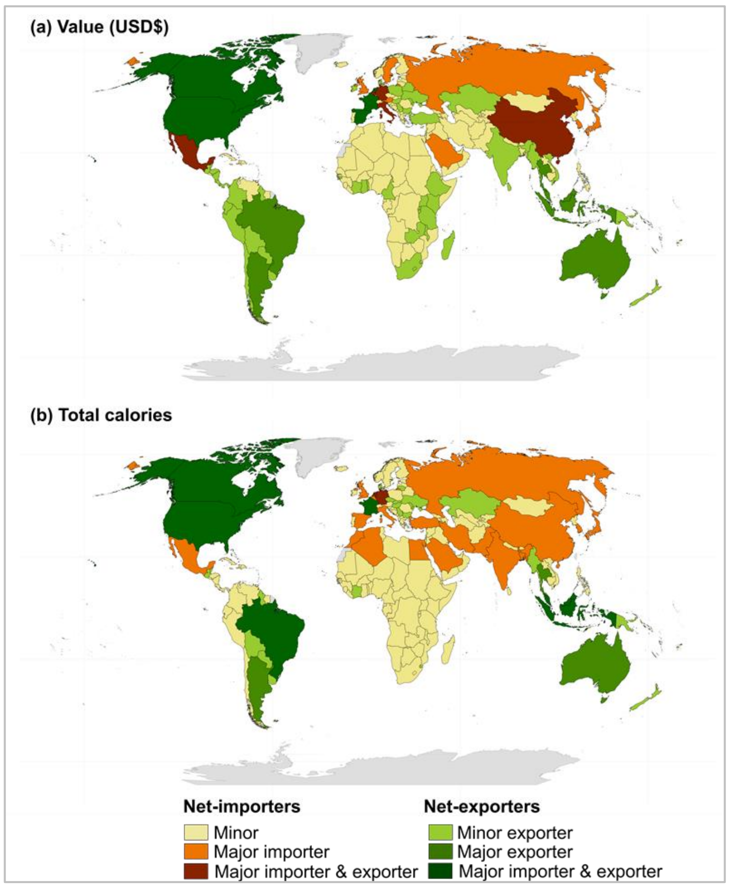

Figure 3.3. Maps of major food trading countries[358]

[357] Graham MacDonald, et al., "Rethinking Agricultural Trade Relationships in an Era of Globalization," *BioScience*, vol. 65, no. 3, 2015, p.279.

[358] Graham MacDonald, et al., "Rethinking Agricultural Trade Relationships in an Era of Globalization," *BioScience*, vol. 65, no. 3, 2015, supplementary data.

MacDonald et al. defined four types of trader countries in terms of cropland area required for trading agricultural products. These are cropland importers, cropland exporters, cropland exchangers, and primarily domestic users. Countries such as China, Mexico, Japan, Netherlands, Saudi Arabia, and South Korea are major importers, while countries such as the US, Brazil, Argentina, Canada, Australia are major exporters.[359] This typology changes slightly in terms of value and calories traded (Figure 3.3).

Virtual water trade is most efficient when agricultural products that need dense irrigation are imported by the water-scarce countries from water-abundant countries. One example is the wheat trade from the US to Egypt. In the US, about 11 percent of wheat production needs irrigation while this share increases to 98 percent in Egypt. The wheat trade from the US to Egypt, "one of the largest global wheat exports," includes about 1.8 cubic kilometers of virtual water traded.[360]

As water supply is limited on a stable level[361] and demand for water tends to be increasing, some studies that lean on the environmental Kuznets curve approach find that there may be hope for a decrease in the water demand depending on development level and an increase in wealth.[362] Water is the foremost input for increasing wealth and achieve an above-mean development level, especially in the

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[359] Graham MacDonald, et al., "Rethinking Agricultural Trade Relationships in an Era of Globalization," *BioScience*, vol. 65, no. 3, 2015, p.286.

[360] Graham MacDonald, et al., "Rethinking Agricultural Trade Relationships in an Era of Globalization," *BioScience*, vol. 65, no. 3, 2015, p.286.

[361] François Molle, "Why Enough Is Never Enough: The Societal Determinants of River Basin Closure," *International Journal of Water Resources Development*, vol. 24, no. 2, 2008.

[362] See, for a selection of articles on water-related environmental Kuznets curve approach: David Stern, "The Rise and Fall of the Environmental Kuznets Curve," *World Development*, vol. 32, no. 8, 2004; Soumyananda Dinda, "Environmental Kuznets Curve Hypothesis: A Survey," *Ecological Economics*, vol. 49, 2004; Maamar Sebri, "Testing the environmental Kuznets curve hypothesis for water footprint indicator: a cross-sectional study," *Journal of Environmental Planning and Management*, vol. 59, no. 11, 2016; Chien-Chiang Lee, Yi-Bin Chiu & Chia-Hung Sun, "The environmental Kuznets curve hypothesis for water pollution: Do regions matter?," *Energy Policy*, vol. 38, no. 1, 2010.

least developed nations as hydraulic works are crucial for basic sectors, such as the agriculture, energy generation, and industrial production. Thus, at the early stage of development, that is to say at a lower level per capita national income, water demand tends to increase significantly. This sharp increase lasts until the per capita national income, or the level of development, reaches a certain level, at which water demand peaks. There are numerous studies in the literature that confirms this hypothesis of water Kuznets curve, yet there is no consensus about the level of development at which the water demand peaks.[363]

3.2.4. Agriculture

Agriculture has a considerable weight in world economy, both in developed and developing countries. In developed countries, agriculture has long been industrialized and food and agriculture are highly subsidized, keeping food prices lower.[364] In developing world, agricultural activities are one of the major sources of employment, national income,[365] food security and reduced unemployment.[366] In that respect, anything that may harm agricultural activity tends to have adverse impacts on social life and economic activity.

As mentioned above, irrigation is by far the largest consumer of freshwater. As of 2014, agriculture is responsible for about 67-70 percent of all freshwater withdrawn in the world.[367] Irrigation is the preferred form of agricultural activity as there is a

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[363] Richard Howitt, "Water Scarcity and the Demand for Water Markets," in K. Burnett, R. Howitt, J.A. Roumasset & C.A. Wada, eds. *Routledge Handbook of Water Economics and Institutions*, 2015, pp.34-38.

[364] Brian Page, "Agriculture," in E. Sheppard & T.J. Barnes, eds. *A Companion to Economic Geography*, 2003, pp.246-49.

[365] Colin Green, *Handbook of Water Economics: Principles and Practice* (W.Sussex: John Wiley & Sons, 2003), p.275.

[366] World Commission on Dams, *Dams and Development: A New Framework for Decision-Making* (London and Sterling: Earthscan, 2000), p.137.

[367] World Bank, "World Development Indicators," *The World Bank Databank*, 2017, available at: http://data.worldbank.org (accessed 31 January 2017). See also: Food and Agriculture

superiority of irrigated agriculture to dryland farming. About one-fifth of the world's farmlands are irrigated and half of the large dams in the world are estimated to be constructed for irrigation purposes.[368] According to Sundquist, irrigated agricultural lands are responsible for 60 percent of the global food outcome in US dollar terms, and 40 percent in terms of amount produced. The productivity is found to increase about 4 to 5 times with irrigation.[369] If the precipitation is not adequate for the agricultural activity or its amount varies considerably throughout the year, then the crops must be irrigated.[370] The amount of irrigation water is an important factor in agricultural processes as excessive irrigation may lead to soil salinization while inadequate irrigation leads to crop failure.[371]

There are important differences between countries regarding freshwater consumption patterns. Many factors may be influencing freshwater withdrawal of agriculture. However, one can argue that less developed countries withdraw most of the water for their agricultural processes. For instance, four out of the five Central Asian republics, Uzbekistan, Turkmenistan, Kyrgyzstan, and Tajikistan consume over 90 percent of their freshwater resources for agricultural processes. In Turkey,

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Organization of the United Nations, *Water Withdrawal by Sector, around 2010*, Aquastat, 2016, available at: http://www.fao.org/nr/Water/aquastat/tables/WorldData-Withdrawal_eng.pdf (accessed 14 August 2017); World Commission on Dams, *Dams and Development: A New Framework for Decision-Making* (London and Sterling: Earthscan, 2000), p.5.

[368] World Commission on Dams, *Dams and Development: A New Framework for Decision-Making* (London and Sterling: Earthscan, 2000), pp.12-13.

[369] Bruce Sundquist, "Irrigated Land Productivity," *Irrigated Lands Degradation: A Global Perspective*, 2007, available at: http://www.civilizationsfuture.com/bsundquist/ir0.html (accessed 31 August 2017).

[370] Colin Green, *Handbook of Water Economics: Principles and Practice* (W.Sussex: John Wiley & Sons, 2003), pp.204-205 and 211.

[371] Colin Green, *Handbook of Water Economics: Principles and Practice* (W.Sussex: John Wiley & Sons, 2003), p.278.

this ratio is 81 percent, in Kazakhstan 66 percent, in Korea 55 percent, in the US 36 percent and in Germany only 1 percent.[372]

As discussed in the case study chapters, the rise of agricultural water demand has some reasons originating from political history. During the Cold War, the two political rivals, the US and the Soviet Union competed not only for political but also for hydropolitical and agricultural supremacy.[373] As of 1986, they were among the top five countries with largest gross irrigated area: 21 thousand hectares in the Soviet Union and 19 thousand hectares in the US. These corresponded to 9 and 10 percent of total global cropland, respectively.[374] During the Cold War, the dominant powers, the US and the Soviet Union, tried to export their agriculture and water management models, both based on government intervention, to their allies through various mechanisms as discussed in this study. The US was more successful in exporting its system to furthest nations, but the spread of the American system led to the questioning of the sustainability of world food production by the 1970s,[375] the decade in which Schumacher urged the world to recognize that humans are using their capital by exploiting the natural resources at an increasing pace.[376]

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[372] World Bank, "World Development Indicators," *The World Bank Databank*, 2017, available at: http://data.worldbank.org (accessed 31 January 2017).

[373] See, for a critical approach to "hydropolitical Cold War": Majed Akhter, "The hydropolitical Cold War: The Indus Waters Treaty and state formation in Pakistan," *Political Geography*, vol. 46, 2015.

[374] Gregory Morris & Jiahua Fan, Reservoir Sedimentation Handbook: Design and Management of Dams: Reservoirs, and Watersheds for Sustainable Use (New York: McGraw-Hill, 1997), p.2.7.

[375] Brian Page, "Agriculture," in E. Sheppard & T.J. Barnes, eds. *A Companion to Economic Geography*, 2003, p.249.

[376] E. Schumacher, *Small Is Beautiful: Economics As If People Mattered* (New York: Perennial Library, 1973).

Both the US and the Soviet Union had large arid regions. In arid regions, agricultural water supply and demand are more problem-prone.[377] Common features of arid regions are short periods of annual precipitation, variability in inter-annual rainfall, low groundwater level and poor recharge of it, intense local rains in short periods, and soil erosion caused by this intense rainwater. In these regions, groundwater usage or rainwater harvesting are options for increasing supply. But the most common method is diverting water from where it is abundant.[378] As stated above, this often requires large irrigation projects with the involvement and support of the national governments.

The involvement of governments in grand hydraulic schemes has been greater in developed countries. Irrigation systems are largely subsidized in Europe or in the US.[379] On the other hand, state involvement in water politics and economics is often linked to other issues such as rural development, reducing food prices, settlement in distant geographies as illustrated in the case of West America, or reducing the pace of migration from rural areas to urban zones.[380] Also, state involvement takes environmental concerns into consideration.[381] Another area of state intervention in

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[377] In the agricultural processes, water is used by the plants (transpiration). Also, some water is lost through evaporation. These processes together are named evapotranspiration. If in a region the precipitation to evapotranspiration ratio is between 0.03 and 0.20, then this region is classified as arid. See: Colin Green, *Handbook of Water Economics: Principles and Practice* (W.Sussex: John Wiley & Sons, 2003), pp.205-06.

[378] Colin Green, *Handbook of Water Economics: Principles and Practice* (W.Sussex: John Wiley & Sons, 2003), pp.131-36.

[379] F. Molle, P.P. Mollinga & P. Wester, "Hydraulic Bureaucracies and the Hydraulic Mission: Flows of Water, Flows of Power," *Water Alternatives*, vol. 2, no. 3, 2009; World Commission on Dams, *Dams and Development: A New Framework for Decision-Making* (London and Sterling: Earthscan, 2000), p.137.

[380] Ruth Meinzen-Dick & Claudia Ringler, "Water Reallocation: Drivers, Challenges, Threats, and Solutions for the Poor," *Journal of Human Development and Capabilities*, vol. 9, no. 1, 2008, p.50; Colin Green, *Handbook of Water Economics: Principles and Practice* (W.Sussex: John Wiley & Sons, 2003), p.282.

[381] Colin Green, *Handbook of Water Economics: Principles and Practice* (W.Sussex: John Wiley & Sons, 2003), pp.282-83.

waterworks is hydropower generation. The following section scrutinizes the hydropower aspect of the transboundary water management issues.

3.3. Hydroelectricity and dams

Dams and reservoirs regulate a great amount of water flow on earth surface. As of 2011, there are more than 58 thousand large dams (higher than 15 meters) registered by the International Commission on Large Dams.[382] This is nearly 50 percent increase in comparison to a quarter century ago when the number of registered large dams was around 39 thousand.[383] Dams are the most common way of supplying irrigation water and producing hydroelectricity. Today, the spots on earth where dam building is simplest are already occupied by existing dams. By the beginning of the 2010s, 22 percent of the total technically feasible potential of hydropower in the world was already developed.[384] Therefore, increasing the number of dams is getting more complicated and economically less feasible as the share of the exploited potential, along with environmental pressures on policymakers, increase.[385]

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[382] International Commission on Large Dams, "General Synthesis," *CIGB/ICOLD*, 2011, available at: www.icold-cigb.org (accessed 20 December 2016).

[383] Gregory Morris & Jiahua Fan, *Reservoir Sedimentation Handbook: Design and Management of Dams: Reservoirs, and Watersheds for Sustainable Use* (New York: McGraw-Hill, 1997), p.2.5; Brian Richter, et al., "Lost in Development's Shadow: The Downstream Human Consequences of Dams," *Water Alternatives*, vol. 3, no. 2, 2010, p.15.

[384] Christiane Zarfl, et al., "A Global Boom in Hydropower Dam Construction," *Aquatic Sciences*, vol. 77, no. 1, 2015, p.162.

[385] See: Trevor Price & Douglas Probert, "Harnessing hydropower: A practical guide," *Applied Energy*, vol. 57, 1997; Jean-Étienne Klimpt, Cristina Rivero, Hannu Puranen & Frans Koch, "Recommendations for Sustainable Hydroelectric Development," *Energy Policy*, vol. 30, 2002; Engelbertus Oud, "The Evolving Context for Hydropower Development," *Energy Policy*, vol. 30, 2002, p.1215.

3.3.1. A general assessment of hydroelectricity

Hydropower has been in use since the first HPPs were built at the end of the nineteenth century.[386] Besides producing electricity, dams are useful for irrigation, navigation, flood control, recreation,[387] and freshwater storage.[388] If there is a large dam with a reservoir, in theory, the water stored in this reservoir can be used in case of necessity and immediate demand.[389] Since a few decades the legitimacy of this was severely questioned with debates on hydroelectric power plants (HPPs) with large reservoirs.[390] Small and micro hydropower, as well as radically designed

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[386] Engelbertus Oud, "The Evolving Context for Hydropower Development," *Energy Policy*, vol. 30, 2002, p.1215.

[387] See: Alison Bartle, "Hydropower Potential and Development Activities," *Energy Policy*, vol. 30, 2002; A. Demirbas, "Focus on the World: Status and Future of Hydropower," *Energy Sources, Part B: Economics, Planning, and Policy*, vol. 2, no. 3, 2007; K. Kaygusuz, "The Role of Hydropower for Sustainable Energy Development," *Energy Sources, Part B: Economics, Planning, and Policy*, vol. 4, no. 4, 2009.

[388] K. Kaygusuz, "The Role of Hydropower for Sustainable Energy Development," *Energy Sources, Part B: Economics, Planning, and Policy*, vol. 4, no. 4, 2009, p.371.

[389] Mark Rosegrant, "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*, 2015, p.14; R. Bakis, "The Current Status and Future Opportunities of Hydroelectricity," *Energy Sources, Part B: Economics, Planning, and Policy*, vol. 2, no. 3, 2007, p.261; K. Kaygusuz, "The Role of Hydropower for Sustainable Energy Development," *Energy Sources, Part B: Economics, Planning, and Policy*, vol. 4, no. 4, 2009; International Renewable Energy Agency, *Renewable Power Generation Costs in 2014*, IRENA, 2015, p.114.

[390] Mitch Beedie, "Hydro – An Environmentally Friendly Source?," *Power-Technology.com*, 2007, available at: http://www.power-technology.com/features/feature1459/ (accessed 16 December 2016); World Commission on Dams, *Dams and Development: A New Framework for Decision-Making* (London and Sterling: Earthscan, 2000), p.18. The old and new approaches to HPP building are investigated by Oud. See: Engelbertus Oud, "The Evolving Context for Hydropower Development," *Energy Policy*, vol. 30, 2002, p.1219. See, for comprehensive discussions on social and environmental impacts of hydropower: R. Sternberg, "Hydropower: Dimensions of social and environmental coexistence," *Renewable & Sustainable Energy Reviews*, vol. 12, no. 6, 2008; D.M. Rosenberg, R.A. Bodaly & P.J. Usher, "Environmental and Social Impacts of Large Scale Hydroelectric Development: Who is Listening?," *Global Environmental Change*, vol. 5, no. 2, 1995; David Rosenberg, et al., "Large-scale impacts of hydroelectric development," *Environmental Reviews*, vol. 5, no. 1, 1997.

green energy dams and plants, are being studied and encouraged among the scientific community in recent years.[391] In addition, environmentalist groups oppose the construction of large dams worldwide. Their efforts are intensified in new dam projects in the developing world as the developed world has already been covered by thousands of large dams during the course of the twentieth century.[392]

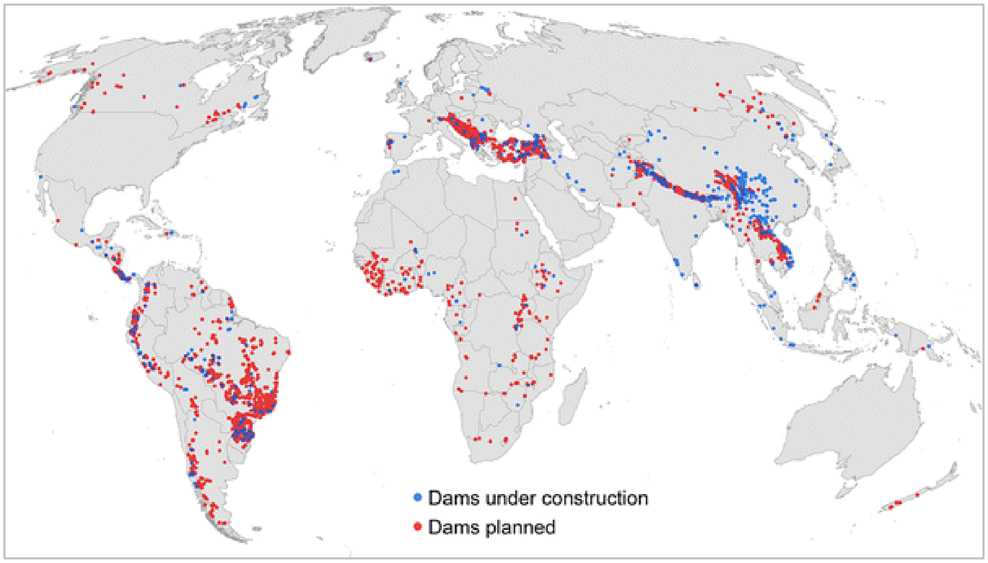

Figure 3.4. Dams planned and under construction as of 2011[393]

In 2000, the publication of the report of the World Commission on Dams was a real milestone for dam advocates and opponents. In general, the report had a critical

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[391] ResearchSEA, "Engineering a multipurpose, environmentally friendly dam," *ScienceDaily*, 2015, available at: https://www.sciencedaily.com/releases/2015/03/150323182619.htm (accessed 16 December 2016).

[392] World Commission on Dams, *Dams and Development: A New Framework for Decision-Making* (London and Sterling: Earthscan, 2000), p.19.

[393] Christiane Zarfl, et al., "A Global Boom in Hydropower Dam Construction," *Aquatic Sciences*, vol. 77, no. 1, 2015, p.165.

tone on large dam projects and suggested alternatives for them. The governments of some dam-building countries, such as China and India, criticized the report.[394] One may observe that the report undermined large dam building projects and impacted international financing, but the efforts continued after a short while (Figure 3.4).[395]

There are five main types of HPPs, which are run-of-river, reservoir, river diversion, pumped storage, and small HPP types.[396] The first type has no or limited water in storage. Water is taken from the stream and sent directly to the tribune. The second type is the conventional reservoir type and depends on gravity for producing electricity from the kinetic energy of water flowing down a dam. The third category generators use some electricity during normal demand times to pump water to a reservoir to produce energy that can be used in cases of peak demand.[397]

Hydropower is a highly efficient system of producing energy. Modern systems generate energy with more than 90 percent efficiency. Usually, the initial costs of HPPs and large dams are quite high, which make them subject to expensive and highly controversial political investment decisions.[398] The decisions are mostly political since the investment requirements often exceed the investment capacity of the private sector, and sometimes the investment capacity of the public sector in some instances (e.g. in Tajikistan).

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[394] Deborah Moore, John Dore & Dipak Gyawali, "The World Commission on Dams + 10: Revisiting the Large Dam Controversy," *Water Alternatives*, vol. 3, no. 2, 2010, p.6.

[395] Julian Kirchherr & Katrina Charles, "The Social Impacts of Dams: A New Framework for Scholarly Analysis," *Environmental Impact Assessment Review*, vol. 60, 2016, p.99.

[396] Dominique Egré & Joseph Milewski, "The Diversity of Hydropower Projects," *Energy Policy*, vol. 30, 2002, pp.1226-27.

[397] International Renewable Energy Agency, *Renewable Power Generation Costs in 2014*, IRENA, 2015, p.115.

[398] Alison Bartle, "Hydropower Potential and Development Activities," *Energy Policy*, vol. 30, 2002, p.1231.

Despite these setbacks and high initial investment costs, in the recent years, there has been an increase in the net installed capacity of hydropower. As of 2014, the total installed capacity reached to 1,061 gigawatts, and in 2015, this capacity rose to 1,211 gigawatts, including pumped storage.[399] With the planned HPP projects, the global installed capacity is expected to grow to about 1,700 gigawatts by 2025-2035. Developing economies, such as China and other Southeast Asian countries, Turkey, the Balkan countries, South American countries, especially Brazil, is expected to dominate this increase to a great extent.[400]

Once completed, electricity production cost per unit is low in hydropower generation business. An International Renewable Energy Agency report indicates that hydroelectricity is one of the cheapest technology of electricity generation. According to the report, the levelized cost of electricity may be as low as 5 cents per kWh on average.[401] The largest part of the expense of an HPP, between 75 and 90 percent of total investment costs, belong to the civil engineering and installed equipment.[402] Operation and maintenance costs are around 2.5 percent to 4 percent of total capital costs, depending on size. The smaller HPPs usually have higher per unit operation and maintenance costs.[403]

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[399] International Hydropower Association, "33 GW new hydropower capacity commissioned worldwide in 2015," *IHA Blog*, 2016, available at: https://www.hydropower.org/blog/33-gw-new-hydropower-capacity-commissioned-worldwide-in-2015 (accessed 2 December 2016).

[400] Christiane Zarfl, et al., "A Global Boom in Hydropower Dam Construction," *Aquatic Sciences*, vol. 77, no. 1, 2015, p.165.

[401] International Renewable Energy Agency, *Renewable Power Generation Costs in 2014*, IRENA, 2015, p.113 and 121.

[402] International Renewable Energy Agency, *Renewable Power Generation Costs in 2014*, IRENA, 2015, p.117.

[403] International Renewable Energy Agency, *Renewable Power Generation Costs in 2014*, IRENA, 2015, pp.118-19.

As discussed in this study, in some regions of the world, hydropower has the potential of ensuring development, especially in Africa and parts of Asia.[404] This is especially valid for petroleum and hydrocarbon importing countries. However, there are major setbacks with regards HPPs and dams. First of all, the reservoirs flood hectares of lands, usually suitable for irrigation and agriculture. Second, they have a considerable impact on ecosystem. As Bakis reminds, a large-size reservoir may transform a terrestrial ecosystem into an aquatic one.[405] Third, the inundated lands lead to a forced relocation of thousands of people. Fourth, trapping of sediments may cause loss of fertility and land erosion. These and further impacts are discussed occasionally in this study.

Regarding total energy supply, also including electricity, hydroelectricity corresponds only to 2.4 percent of world total primary energy supply, as of 2014. When compared to four decades ago, in 1973, hydropower corresponded to 1.8 percent of the total. The share of oil has dropped from 46 to 31 percent, and coal dropped from 29 to 24 percent in forty years, while the share of natural gas increased from 16 to 21 percent.[406] According to UN data, in the last decades, renewable energy share[407] in total final energy consumption has slightly grown in the world. In general, developing regions are the major consumers of renewable energy, yet their share of renewables consumption has decreased while the proportion of the developed countries has increased. This is an indicator that there is a trend of greater con-

[404] Alison Bartle, "Hydropower Potential and Development Activities," *Energy Policy*, vol. 30, 2002, pp.1232-35; R. Sternberg, "Hydropower's future, the environment, and global electricity systems," *Renewable & Sustainable Energy Reviews*, vol. 14, no. 2, 2010, pp.719-20.

[405] R. Bakis, "The Current Status and Future Opportunities of Hydroelectricity," *Energy Sources, Part B: Economics, Planning, and Policy*, vol. 2, no. 3, 2007, p.262.

[406] International Energy Agency, *Key World Energy Statistics*, IEA, 2016, p.6.

[407] According to International Energy Agency, hydroelectricity corresponds to 85 percent of world's total renewable electricity generation. See: International Energy Agency, *Technology Roadmap: Hydropower*, IEA, 2012, p.7.

sciousness in the developed countries of the necessity for an increase in the renewable energy production (Figure 3.5). Also, since the beginning of the 2010s, there is a significant decrease in the investment costs of the renewable energy due to improved technology. The most significant decrease was in the cost of solar photovoltaic technology with about two-thirds decrease between 2010 and 2016.[408]

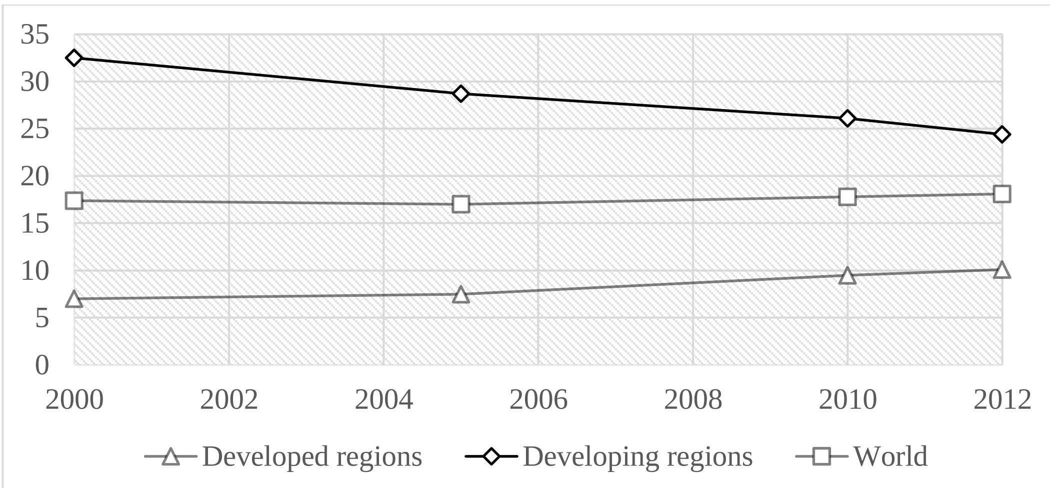

Figure 3.5. Renewable energy share in the total final energy consumption[409]

According to International Energy Agency, as of 2014, 16 percent of the total electricity production in the world has its source from hydropower (Figure 3.6). The world produced nearly 24,000 TWh of electricity, of which nearly 41 percent from

[408] REN21, *Renewables 2017 Global Status Report*, Renewable Energy Policy Network for the 21st Century, 2017, p.91.

[409] United Nations, "Renewable energy share in the total final energy consumption," *UN Data*, 2016, available at: http://data.un.org/Data.aspx?q=energy&d=SDGs&f=series%3aEG_FEC_RNEW (accessed 29 November 2016).

coal, 22 percent from natural gas, 11 percent from nuclear and 4 percent from oil.[410] China generated nearly one-fourth of the world's total electricity.[411] The World Energy Council estimates that theoretically 39,000 TWh of electricity can be produced using water resources around the globe, of which 16,000 TWh is economically feasible to develop.[412]

International energy data indicate that China has been the leading nation since a while regarding installed hydropower capacity and hydroelectricity production. The second and third places may change, but the US, Canada and Brazil are leading players in hydropower business. China, with its huge and growing economy, produces more than one-fourth of total world hydroelectricity, yet it produces only 18.7 percent of its total electricity from HPPs.[413] As of 2016, the leading countries in terms of total installed capacity are China (305 gigawatts), Brazil (97 gigawatts), the US (80 gigawatts), Canada (79 gigawatts), Russia (48 gigawatts). About 28 percent of the total global installed hydropower capacity is in China.[414] China added 8.9 gigawatts to its generating capacity in 2016 alone and is the leader in terms of newly added capacity as well. China is followed by Brazil with 5.3 gigawatts added capacity, followed by Ecuador (2.0), Ethiopia (1.5), Viet Nam (1.1), Peru (1.0), Turkey (0.8), Laos (0.7), and Malaysia (0.6).[415] The US possesses the third largest hydropower generating capacity in the world. This corresponds to approximately 6 percent of its total electricity generation. In the US, more recently, there is a general

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[410] International Energy Agency, *Key World Energy Statistics*, IEA, 2016, p.24.

[411] International Energy Agency, *Key World Energy Statistics*, IEA, 2016, p.26.

[412] Zhenya Liu, *Global Energy Interconnection* (Amsterdam: Elsevier, 2015), p.19.

[413] International Energy Agency, *Key World Energy Statistics*, IEA, 2016, p.19.

[414] REN21, *Renewables 2017 Global Status Report*, Renewable Energy Policy Network for the 21st Century, 2017, p.169. The REN21 report gives the total global installed hydropower capacity as of end-2016 as 1,096 gigawatts, and 1,246 gigawatts including 150 gigawatts pumped storage.

[415] REN21, *Renewables 2017 Global Status Report*, Renewable Energy Policy Network for the 21st Century, 2017, p.57.

increase in the amount of electricity generated by the HPPs. Especially in the West, California has doubled its hydropower generation in 2016.[416] On the other hand, a cautious approach is embraced in the US for building new dams.

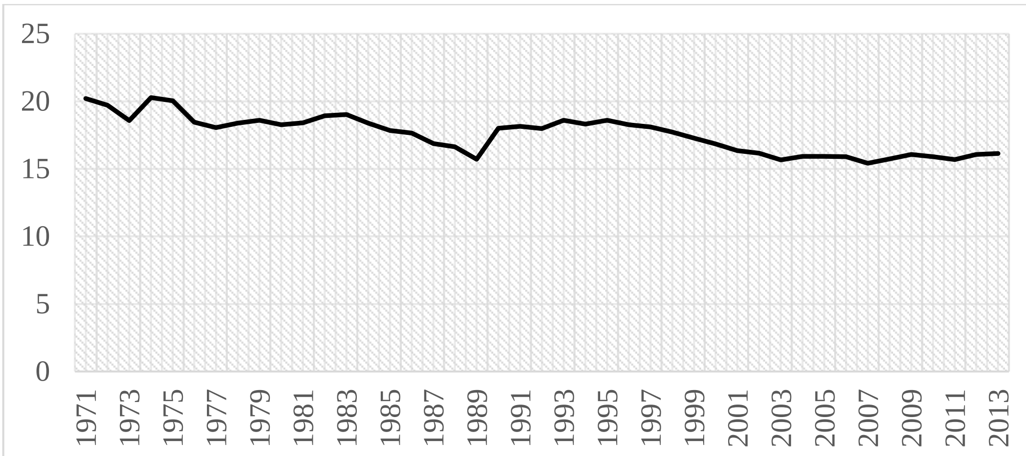

Figure 3.6. World hydroelectricity production as percent of total[417]

China is a net exporter of electricity. The leading exporter in the world is France, with 67 TWh of electricity exports, followed by Canada, Paraguay, and Germany. The US is a net importer with 53 TWh of electricity imports, followed by Italy, Brazil and the UK.[418] For this electricity trade to take place, serious investments in transboundary high-voltage transmission lines are made globally, and a significant number of new interconnection projects are in pipeline. One of the main aims of

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[416] REN21, *Renewables 2017 Global Status Report*, Renewable Energy Policy Network for the 21st Century, 2017, p.59.

[417] World Bank, "Electricity production from hydroelectric sources (% of total)," *World Development Indicators*, 2014, available at: http://data.worldbank.org/indicator/EG.ELC.HYRO.ZS (accessed 30 November 2016).

[418] International Energy Agency, *Key World Energy Statistics*, IEA, 2016, p.27.

this study is analyzing the transboundary electricity transfers and their impacts on water development projects.

Some countries in the basins analyzed in this study are relatively less advantageous in terms of access to electricity. For instance, the level of access to clean energy is low in the upstream Nile river basin, which is in stark contrast to the Columbia river basin, and comparable to the Mekong river basin (Figure 3.7).[419] In these countries, the priority of the governments and the international development agencies tend to be economic growth through generation of hydroelectricity and possible regional electricity trading options.

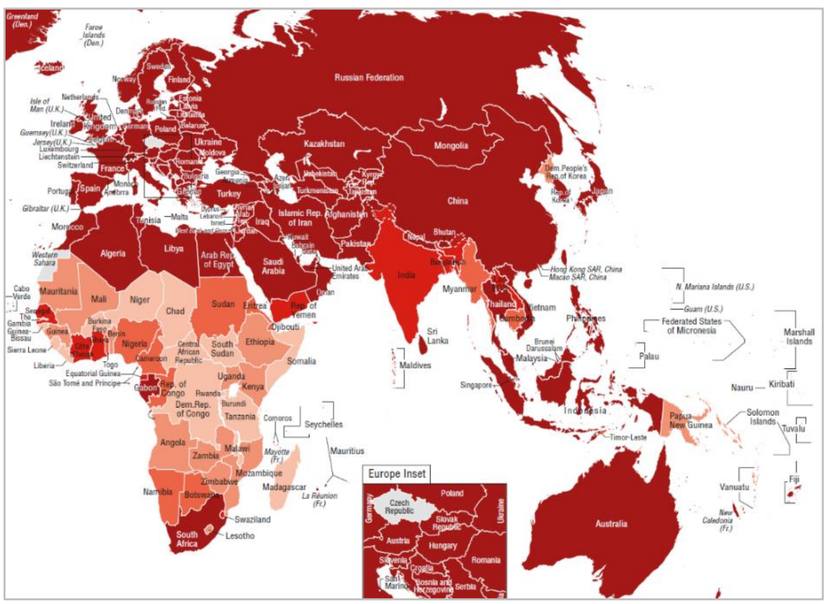

Figure 3.7. Access to clean energy in Asia and Africa[420]

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[419] World Bank, Atlas of Sustainable Development Goals 2017: World Development: World Development Indicators, The World Bank, 2017, p.41.

[420] World Bank, Atlas of Sustainable Development Goals 2017: World Development: World Development Indicators, The World Bank, 2017, p.41. Darker color indicates to a higher level of access to clean energy.

3.3.2. Water, environment and hydroelectricity

Water and electricity trade may have impacts on the environment as well. Large irrigation works often involve long networks of irrigation canals and large reservoirs. The length of irrigation networks has some impacts on the environment. First of all, the longer the network, the wider the surface area of the irrigation system, which increases evaporation in arid and temperate climates. Sometimes water in a catchment is naturally evaporated in shallow and wide wetlands, such as the Sudd in the upstream Nile river basin.[421] The impact further increases if the water transport is directed to an agricultural region out of the catchment. In such cases, like those allegedly planned in China, the water in the basin is completely lost. Second, if the irrigation water travels long distances and blends with local waters, then the composition of the local water, such as its hardness, temperature, flow regime, changes. This may influence the living conditions of some species and even lead to a total extinction. Third, the newly established connections between the water bodies may lead the transfer of species from one region to another.[422] These may harm the local ecosystem.

Hydroelectricity production, as stated above, is often regarded as clean and renewable.[423] This claim has been challenged some studies.[424] As Orr et al. observe, the construction of dams and reservoirs "always created conflicts between energy sup-

[421] Y. Mohamed, B. Hurk, Hubert Savenije & W.G.M. Bastiaanssen, "Impact of the Sudd wetland on the Nile hydroclimatology," *Water Resources Research*, vol. 41, no. 8, 2005.

[422] Colin Green, *Handbook of Water Wconomics: Principles and Practice* (West Sussex: John Wiley & Sons, 2003), p.294.

[423] Gary Frey & Deborah Linke, "Hydropower as a Renewable and Sustainable Energy Resource Meeting Global Energy Challenges in a Reasonable Way," *Energy Policy*, vol. 30, 2002.

[424] See, for example: Luc Gagnon & Joop Vate, "Greenhouse gas emissions from hydropower: The state of research in 1996," *Energy Policy*, vol. 25, no. 1, 1997; Amit Kumar & M.P. Sharma, "Greenhouse Gas Emissions from Hydropower Reservoirs," *Hydro Nepal: Journal of Water, Energy and Environment*, vol. 11, 2012.

ply and related economic interests, versus their social and environmental impacts."[425] As the global population growth and demand for greater economic and social wealth continues, especially in the developing economies, dams tend to continue to be the primary choice of the policymakers that aim to bolster development.[426]

Hydroelectricity production consumes considerable amounts of blue water. The main reason for this consumption is the evaporation of water in large reservoirs because of increased surface area of water. In a 2015 study, Zhao and Liu summarize the approaches assessing the water footprint of hydroelectricity production. Accordingly, there are three main assessment methods. The first is the gross water consumption method, evaluating the gross amount of water evaporates from the reservoir. Second is the net water consumption method, taking into consideration the evaporation amount before the construction of the dam and subtracting it from the gross water evaporation. Finally, the third is the water balance method, taking into account the difference between annual inputs to and outputs from the reservoir.[427] The authors suggest that a new method can be developed that distinguishes hydroelectricity production from other uses of the dam. In other words, the water consumption of a reservoir for its functions of flood control, recreation, navigation, water supply and agriculture can be separated from hydroelectricity production function by using an allocation coefficient based on the weight of economic

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[425] Stuart Orr, Jamie Pittock, Ashok Chapagain & David Dumaresq, "Dams on the Mekong River: Lost Fish Protein and the Implications for Land and Water Resources," *Global Environmental Change*, vol. 22, no. 4, 2012, p.926.

[426] See, for a comprehensive assessment: Ji Chen, Haiyun Shi, Bellie Sivakumar & M. Peart, "Population, water, food, energy and dams," *Renewable and Sustainable Energy Reviews*, vol. 56, 2016.

[427] Dandan Zhao & Junguo Liu, "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*, vol. 79-82, 2015, p.41.

value of these individual functions.[428] Although the authors assume that reservoirs consume only blue water and no gray water is consumed during the hydroelectricity production, research indicates to negative impacts of HPPs on water quality[429] and the environment.[430] The impact is high in large dams with great reservoirs, but moderate dams have impacts as well.[431]

Studying a reservoir in China, Wei et al. found that dams decrease water quality in the reservoirs in the long run, although there may be some improvement in the water quality for a short while.[432] Another study shows that the water quality of the river stream may be severely affected by the construction of dams.[433] These studies generally refer to contamination of the reservoir water. Some scholars also argue that the water quality in the lower part of a basin downstream of a dam generally

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[428] Dandan Zhao & Junguo Liu, "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*, vol. 79-82, 2015, pp.42-45.

[429] GuoLiang Wei et al., "Impact of Dam Construction on Water Quality and Water Self-Purification Capacity of the Lancang River, China," *Water Resources Management*, vol. 23, no. 9, 2009.

[430] Molly Pohl, "Channel Bed Mobility Downstream from the Elwha Dams, Washington," *The Professional Geographer*, vol. 56, no. 3, 2004; Ian Campbell, "The Challenges for Mekong River Management," in I. Campbell, ed. *The Mekong: Biophysical Environment of an International River Basin* 1st ed., 2009.

[431] See: Molly Pohl, "Channel Bed Mobility Downstream from the Elwha Dams, Washington," *The Professional Geographer*, vol. 56, no. 3, 2004, p.430; Emily Stanley, Michelle Luebke, Martin Doyle & David Marshall, "Short-Term Changes in Channel Form and Macroinvertebrate Communities Following Low-Head Dam Removal," *Journal of the North American Benthological Society*, vol. 21, no. 1, 2002, pp.185-86; Bryan Tilt, Yvonne Braun & Daming He, "Social impacts of large dam projects: A comparison of international case studies and implications for best practice," *Journal of Environmental Management*, vol. 90, 2009; Philip Brown, et al., "Modeling the costs and benefits of dam construction from a multidisciplinary perspective.," *Journal of Environmental Management*, vol. 90, 2009.

[432] GuoLiang Wei et al., "Impact of Dam Construction on Water Quality and Water Self-Purification Capacity of the Lancang River, China," *Water Resources Management*, vol. 23, no. 9, 2009, pp.1776-77.

[433] Ahmet Kurunc, Kadri Yurekli & Cengiz Okman, "Effects of Kilickaya Dam on Concentration and Load Values of Water Quality Constituents in Kelkit Stream in Turkey," *Journal of Hydrology*, vol. 317, 2006.

remains unaffected.[434] In general, the impact of dams on river ecosystems, water quality, health,[435] and other factors that are related to socioeconomic and political outcomes are well documented and discussed for a while in the relevant literature. Another major impact of large dams is on fisheries, even in the presence of fish passages or fish ladders.[436] Another impact of the dams on rivers is sediment accumulation or sedimentation.[437] This can be a major issue in river basins with dense agricultural activity. Also, most large dam projects require thousands of people, usually poor, to be relocated. In such cases, farmland and pastures of the rural population gets inundated and these people have to leave these lands.[438] As a general trend, dam removal was seen as an important and viable alternative for decreasing the negative effects of these structures,[439] along with other factors such as dam safety, increasing costs of maintenance, environmental concerns, or reduced benefits from the dam. In the twentieth century, 587 dams were decommissioned in the

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[434] Daming He et al., "Transboundary Hydrological Effects of Hydropower Dam Construction on the Lancang River," *Chinese Science Bulletin*, vol. 51, no. 22, 2006, p.24.

[435] Leonard Lerer & Thayer Scudder, "Health impacts of large dams," *Environmental Impact Assessment Review*, vol. 19, no. 2, 1999.

[436] Stuart Orr, Jamie Pittock, Ashok Chapagain & David Dumaresq, "Dams on the Mekong River: Lost Fish Protein and the Implications for Land and Water Resources," *Global Environmental Change*, vol. 22, no. 4, 2012, p.926; Mark Rosegrant, "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*, 2015, p.17.

[437] Gregory Morris & Jiahua Fan, Reservoir Sedimentation Handbook: Design and Management of Dams: Reservoirs, and Watersheds for Sustainable Use (New York: McGraw-Hill, 1997).

[438] See, for a comprehensive study for the Upper-Mekong region: P. Wang, J. Lassoie, S. Dong & S. Morreale, "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*, vol. 117, 2013.

[439] Emily Stanley, Michelle Luebke, Martin Doyle & David Marshall, "Short-Term Changes in Channel Form and Macroinvertebrate Communities Following Low-Head Dam Removal," *Journal of the North American Benthological Society*, vol. 21, no. 1, 2002, pp.172-73.

US. This trend gained pace recently as between 1995 and 2000, the number of dam removals reached 140.[440]

Small hydropower is generally[441] accepted as more environment-friendly.[442] In this type of HPPs, there is no or only a small dam with a small reservoir.[443] Because of the small size, the efficiency of small hydropower generators is usually lower than the large turbines.[444] Regarding cost efficiency, high head, i.e. higher than 50 meters, small HPPs are more cost effective than lower head types. Low head small HPPs are more common, and most of them are usually not attractive as an investment choice.[445]

Climate change is closely related to energy and electricity production. The Paris Agreement under the UN Framework Convention on Climate Change was signed in April 2016 in New York and effective as of November 2016. As of 16 December 2016, 118 parties signed the text, corresponding 80 percent of all global emissions. China and the US, two major sources of greenhouse gasses globally with their 20 and 18 percent contributions to global emissions, respectively, ratified the agree-

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440 Suzanne Pritchard, "It didn't start with Edwards," *Water Power and Dam Construction*, 2001, available at: http://www.waterpowermagazine.com/features/featureit-didn-t-start-with-edwards/ (accessed 30 August 2017).

441 See, for a discussion on the impacts of small hydropower schemes: Tasneem Abbasi & S.A. Abbasi, "Small hydro and the environmental implications of its extensive utilization," *Renewable & Sustainable Energy Reviews*, vol. 15, no. 4, 2011, pp.2139-40.

442 Gary Frey & Deborah Linke, "Hydropower as a Renewable and Sustainable Energy Resource Meeting Global Energy Challenges in a Reasonable Way," *Energy Policy*, vol. 30, 2002.

443 Oliver Paish, "Small Hydro Power: Technology and Current Status," *Renewable and Sustainable Energy Reviews*, vol. 6, 2002, p.538.

444 Oliver Paish, "Small Hydro Power: Technology and Current Status," *Renewable and Sustainable Energy Reviews*, vol. 6, 2002, p.540.

445 Oliver Paish, "Small Hydro Power: Technology and Current Status," *Renewable and Sustainable Energy Reviews*, vol. 6, 2002, p.548.

ment. The fourth contributor, Russia, has not ratified the treaty yet. Russia and Turkey are the two G20 countries that did not ratify the agreement as of mid-December 2016.[446]

Perhaps the key to the Paris Agreement is energy production, a process that is responsible for at least two-thirds of global emissions of greenhouse gasses. Therefore, as the International Energy Agency argues, "transformative change in the energy sector" is essential in order the agreement to reach its aims.[447] Renewable energy and electricity production is an important aspect of this transformation. As of 2015, the increase in the amount of greenhouse gasses that is related to energy generation has stopped.[448] The agency stresses that the water and energy nexus would intensify in the coming decades because of the rising energy demand of water[449] and irrigation processes and of water demand for energy production, yet the trend here is also optimistic: the development of more efficient cooling technologies require less water that must be withdrawn from the reservoirs.[450]

Electricity integration can support environmental policies, as suggested by Burgos. Integrated electricity systems and pooling of resources have the potential of sup-

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[446] The member states that did not sign the Agreement are Nicaragua, Syria and Uzbekistan. See: Potsdam Institute for Climate Impact Research, "Entry Into Force of the Paris Agreement," *Paris Reality Check - Pledged Climate Futures*, 2016, available at: https://www.pik-potsdam.de/primap-live/entry-into-force/ (accessed 21 December 2016); Climate Analytics, "Paris Agreement Ratification Tracker," *Climate Analytics*, 2016, available at: http://climateanalytics.org/hot-topics/ratification-tracker.html (accessed 21 December 2016).

[447] International Energy Agency, *World Energy Outlook 2016*, OECD/IEA, 2016b, p.21.

[448] International Energy Agency, *World Energy Outlook 2016*, OECD/IEA, 2016b, p.21.

[449] Water sector demanded 120 Mtoe of energy in 2014, principally in the form of electricity. International Energy Agency, *World Energy Outlook 2016*, OECD/IEA, 2016b, p.347.

[450] See: Subsection 2.5.1 for a discussion. International Energy Agency, *World Energy Outlook 2016*, OECD/IEA, 2016b, p.347.

porting renewable electricity production and higher efficiency in electricity generation.[451] This requires coordinated energy policies, strong institutions and regulation[452] among countries with varying sources of energy. For instance, coal-fueled generators in a country with lower potential of hydro or solar power can be supported by renewables in neighboring countries in cases of peak demand. On the other hand, integration can have adverse effects too, especially in liberalized and non-regulated energy markets. The private generators can prefer lower cost power plants for electricity production by building coal or gas-fired plants.[453] Though one should bear in mind that the steady decline in solar power installed costs will make photovoltaic cells a more sustainable and preferable source of electricity generation, in comparison to fossil-fuel generators.[454]

3.4. Interconnections

Electricity is transferred through cables or lines. “A cable or overhead line connecting two separate market or pricing areas” is named interconnector.[455] An interconnector can be built in the form of alternating current and direct current. The former

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[451] Francisco Burgos, Regional electricity cooperation and integration in the Americas: Potential environmental, social and economic benefits, Organization of the American States, 2007, p.2.

[452] Francisco Burgos, Regional electricity cooperation and integration in the Americas: Potential environmental, social and economic benefits, Organization of the American States, 2007, p.11.

[453] Francisco Burgos, Regional electricity cooperation and integration in the Americas: Potential environmental, social and economic benefits, Organization of the American States, 2007, pp.2-3.

[454] For more information, see: Galen Barbose & Naïm Darghouth, *Tracking the Sun IX: The Installed Price of Residential and Non-Residential Photovoltaic Systems in the United States*, Berkeley Lab & US Department of Energy, 2016; Mark Bolinger & Joachim Seel, *Utility-Scale Solar 2015: An Empirical Analysis of Project Cost, Performance, and Pricing Trends in the United States*, Berkeley Lab & US Department of Energy, 2016; Katie Fehrenbacher, "Solar Is Going to Get Ridiculously Cheap," *Fortune*, 2016, available at: http://fortune.com/2016/06/13/solar-to-get-crazy-cheap/ (accessed 11 January 2017); Jess Shankleman & Chris Martin, "Solar Could Beat Coal to Become the Cheapest Power on Earth," *Bloomberg*, 2017, available at: https://www.bloomberg.com/news/articles/2017-01-03/for-cheapest-power-on-earth-look-skyward-as-coal-falls-to-solar (accessed 11 January 2017).

[455] Ralph Turvey, "Interconnector Economics," *Energy Policy*, vol. 34, 2006, p.1457.

type can only be used between synchronous frequency systems.[456] Throughout the world, electricity production reached to nearly 25 thousand TWh, of which nearly half is produced by three countries, China (6,015 TWh), the US (4,327 TWh), and India (1,423 TWh).[457] Electricity consumption reached to 21.2 thousand TWh in 2016, again, slightly less than half is consumed by the same three countries, with 5,219 TWh in China, 3,867 TWh in the US, and 1,065 TWh in India.[458] This roughly means that electricity is consumed where it was generated. On the other hand, there is a significant electricity trade globally (Figure 3.8).

In the history, the first attempts of electricity transmission were with direct current. In the early years of electricity technology, electric-powered machines must be located next to the generators to avoid the need for transmission of electricity in long distances. In the late nineteenth century, in 1882, Thomas Edison established the electricity distribution systems in Manhattan and New Jersey.[459] In the same year, another trial was in Europe, at the Electrical Exhibition in Munich, during which a 2 kV line was constructed between the Bavarian Alps and Miesbach. The efficiency of the system was measured 50 percent.[460] In 1889, a 10 kV alternating current line was built to London, from 45 km distance at Deptford alternating current power

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[456] Ralph Turvey, "Interconnector Economics," *Energy Policy*, vol. 34, 2006, p.1458; Zhenya Liu, *Ultra-High Voltage AC/DC Grids* (Amsterdam: Elsevier, 2015), p.2.

[457] Enerdata, "Electricity Production," *Global Energy Statistical Yearbook*, 2016, available at: https://yearbook.enerdata.net/electricity/world-electricity-production-statistics.html (accessed 12 October 2017).

[458] Enerdata, "Eelctricity Consumption," *Global Statistical Yearbook*, 2016, available at: https://yearbook.enerdata.net/electricity/electricity-domestic-consumption-data.html (accessed 12 October 2017).

[459] Matthew Brown & Richard Sedano, *Electricity Transmission: A Primer* (Washington, DC: National Council on Electric Policy, 2004), p.2.

[460] Massimo Guarnieri, "The Beginning of Electric Energy Transmission: Part One," *IEEE Industrial Electronics Magazine*, vol. March, 2013, p.51.

plant.[461] George Westinghouse constructed an 11 kV alternating current line in 1896, from the HPP at Niagara Falls to Buffalo. In the following years, the voltage used in alternating current lines increased steadily. In the 1930s, the voltage reached to 240 kV. This enabled even larger electricity utilities to be built.[462]

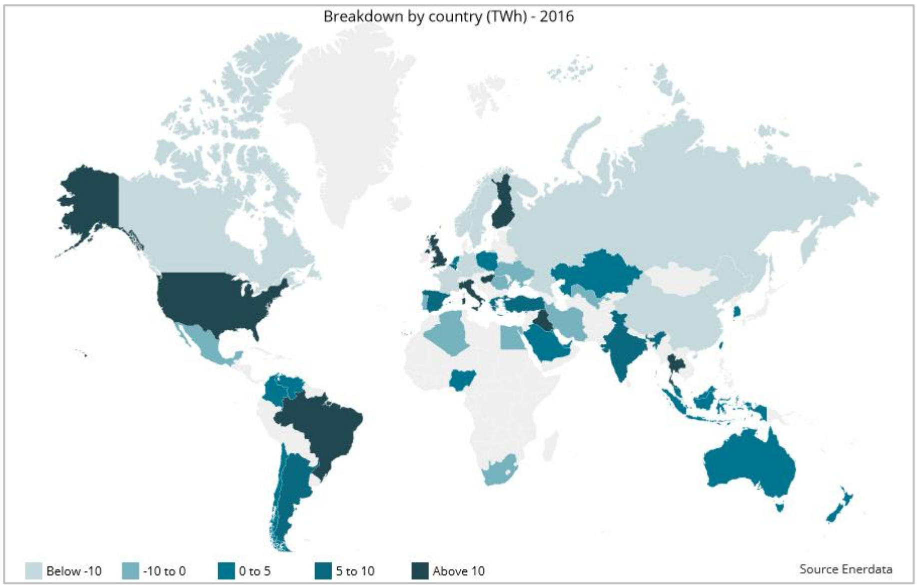

Figure 3.8. World electricity trade, in TWh[463]

[461] Massimo Guarnieri, "The Beginning of Electric Energy Transmission: Part Two," *IEEE Industrial Electronics Magazine*, vol. June, 2013, p.52.

[462] Matthew Brown & Richard Sedano, *Electricity Transmission: A Primer* (Washington, DC: National Council on Electric Policy, 2004), p.2.

[463] Enerdata, "Electricity Trade," *Global Energy Statistical Yearbook*, 2016, available at: https://yearbook.enerdata.net/electricity/electricity-balance-trade.html (accessed 12 October 2017).

Energy transfers need at least two basic elements, which are transmission lines and transformers. Transmission lines carry electricity at high voltage, extra-high voltage, or at ultra-high voltage[464] to transformers, where the voltage is reduced to low levels for commercial or household consumption.[465] Transnational electricity trade is made possible through transmission lines, the interconnectors. In a region, if all electricity utilities are connected, then the region is called as a frequency area or an interconnection. In the interconnections, the utilities function at a synchronized frequency, which is 50 Hz for Europe and 60 Hz for North America.[466] This is important since a failure in this synchronous system would lead a total blackout. Examples of such blackouts occurred in the US in 1965, in Italy in 2003, and in Turkey in 2015.[467]

In a transmission network, all electricity providers deliver electricity to final customers through a shared and single transmission grid. Thus, the reliability of the transmission network is of crucial importance. In parallel, the behaviors of the electricity market participants must be closely monitored and regulated as some acts of individual participants may harm the proper functioning of whole systems. For example, a supplier may reduce the amount of electricity it provides to the network with the expectation of higher revenues caused by lower supply may have adverse

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[464] High voltage is defined as the voltage between 35 to 220 kV, extra-high voltage ranges between 330 and 1,000 kV, and ultra-high voltage is 1,000 kV or higher. See: Zhenya Liu, *Ultra-High Voltage AC/DC Grids* (Amsterdam: Elsevier, 2015), p.2.

[465] Matthew Brown & Richard Sedano, *Electricity Transmission: A Primer* (Washington, DC: National Council on Electric Policy, 2004), p.29.

[466] Manuel Baritaud & Dennis Volk, *Seamless Power Markets: Regional Integration of Electricity Markets in IEA Member Countries*, International Energy Agency, 2014, p.14.

[467] Manuel Baritaud & Dennis Volk, *Seamless Power Markets: Regional Integration of Electricity Markets in IEA Member Countries*, International Energy Agency, 2014, pp.14-15.

effects on system reliability.[468] This act of exercising market power by such a supplier may usually be compensated with an increase in generation by other providers in the same market. If the market power exerciser is at a distant location and the transaction costs of other suppliers are high, this compensation mechanism may not work. Here, the only solution seems to be decreasing the operation costs.[469]

As Newbery notes, liberalized electricity markets may be unstable without adequate regulation. According to the author, there are three requirements for a healthy and integrated market liberalization. The first requirement is the access of electricity suppliers to transmission networks. To ensure this, the transmission and generation facilities are often separated from each other. The second is supply security. For this to be achieved, the transmission network capacity must be adequate and reliable; electricity production levels must be appropriate for a foreseeable future; and the supply of primary fuels for electricity generation, such as oil, gas, or water must be secured. And finally, markets must be regulated and supervised.[470]

3.4.1. The economy of electricity interconnection

Integrating electricity markets is a priority for a variety of regions over the globe. Moving a step further, establishment of global energy interconnections are being discussed in the literature and policy circles.[471] The International Electrotechnical Commission supports the connection of all the grids on the world through ultra-

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468 Frank Wolak, *Lessons from International Experience with Electricity Market Monitoring*, University of California Energy Institute, 2004, p.3.

469 Richard Pierce, Michael Trebilcock & Evan Thomas, "Beyond Gridlock: The Case for Greater Integration of Regional Electricity Markets," *C.D. Howe Institute Commentary*, vol. 228, 2006, p.6.

470 David Newbery, "Problems of Liberalising the Electricity Industry," *European Economic Review*, vol. 46, 2002, pp.920-21.

471 Zhenya Liu, *Global Energy Interconnection* (Amsterdam: Elsevier, 2015). See Chapter 5, especially.

high voltage transmission lines.[472] On the other hand, it is not uncommon, especially in the developing countries, that the political leaders seek energy and electricity self-sufficiency for their countries as they see energy as a strategic input for economic development.[473] This has resulted in giant, often state-controlled and vertically integrated energy companies holding the monopoly of electricity, along with national grids operating in isolation. As a relatively recent trend for developing countries, the electricity distribution companies are being separated and privatized.

Van Den Hoven and Froschauer examined the development of the theory and rhetoric of international energy market liberalization and how some developed countries pursued national interest in international energy transaction policies.[474] In the 1980s, as a trend emanated from the US and the UK, the legitimacy of the state monopoly on integrated electricity companies began to be questioned. The US and the UK undergone some radical reforms in their electricity industry and market structure and this affected the perceptions of international electricity trade. The literature and leading international organizations[475] expected that all other countries would follow the examples of the US and the UK. The literature on liberalization of transnational electricity transfers and electricity markets emphasize some points in that respect. Accordingly, states must undergo changes in access to transmission grid; ensure electricity consumers choose between electricity companies,

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[472] International Electrotechnical Commission, *Global Energy Interconnection*, International Electrotechnical Commission, 2017, available at: http://www.iec.ch/whitepaper/pdf/iecWP-globalenergyinterconnection.pdf (accessed 10 October 2017), pp.18-19.

[473] Manuel Baritaud & Dennis Volk, *Seamless Power Markets: Regional Integration of Electricity Markets in IEA Member Countries*, International Energy Agency, 2014, pp.22-23.

[474] Adrian Van den Hoven & Karl Froschauer, "Limiting Regional Electricity Sector Integration and Market Reform: The Cases of France in the EU and Canada in the NAFTA Region," *Comparative Political Studies*, vol. 37, no. 9, 2004.

[475] Some examples of these international organizations are: the United Nations, the World Bank, the World Energy Council, the Organization for American States, and the Commission for Environmental Cooperation. See: Pierre-Olivier Pineau, *Integrating Electricity Sectors in Canada: Good for the Environment and for the Economy*, The Federal Idea, 2012, p.4.

disintegration, and privatization of the national electricity monopolies; encourage a regulated competition; make arbitrage available, and facilitate the international trade of electricity.[476]

Unlike hydrocarbon resources that are traded in global markets at single prices, electricity markets remained local and isolated[477] because of lack of integration in electricity markets. Economically, an integrated electricity market means that the price of electricity is the same across the integrated market and differs only by transfer costs.[478] The longer the distance of transmission line, the higher should be the transfer costs as long lines cause higher losses of electric power due to increased resistance.[479] Charpentier and Schenk give some important factors for electricity trade. First is the harmonization of domestic power sectors of trading countries. A deterioration in this harmonization would result in deterioration of trade. Second, an arrangement of pooling must be completed. A trading center and a control center must be established. This is crucial for the maintenance of the stability of the system. The third factor is about transit rights, meaning “open access and free transit” for electricity transmission lines.[480]

In Europe, power integration is one of the principal items on the agenda of EU. To achieve this, EU has been endeavoring to introduce a coupling mechanism of prices

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[476] Adrian Van den Hoven & Karl Froschauer, "Limiting Regional Electricity Sector Integration and Market Reform: The Cases of France in the EU and Canada in the NAFTA Region," *Comparative Political Studies*, vol. 37, no. 9, 2004, p.1082.

[477] Richard Pierce, Michael Trebilcock & Evan Thomas, "Beyond Gridlock: The Case for Greater Integration of Regional Electricity Markets," *C.D. Howe Institute Commentary*, vol. 228, 2006, p.1.

[478] Richard Pierce, Michael Trebilcock & Evan Thomas, "Beyond Gridlock: The Case for Greater Integration of Regional Electricity Markets," *C.D. Howe Institute Commentary*, vol. 228, 2006, p.2.

[479] Richard Pierce, Michael Trebilcock & Evan Thomas, "Beyond Gridlock: The Case for Greater Integration of Regional Electricity Markets," *C.D. Howe Institute Commentary*, vol. 228, 2006, p.2

[480] J. Charpentier & K Schenk, International Power Interconnections: Moving from electricity exchange to competitive trade, The World Bank, 1995, p.3.

since 2006,[481] and initiated a trilateral market coupling between France, Belgium, and the Netherlands. In 2010, the Central Western Europe zone that includes the Benelux countries, along with France, Germany, and Austria, as well as Southwestern Europe with Spain and Portugal were established. In 2014, Northwestern Europe was included in the coupling with the inclusion of the Baltic States, Scandinavia, the UK, and Poland. Later in the same year, Czech Republic, Slovakia, Hungary, and Romania were also involved. A year later, Italy and its neighbors joined. The interconnected area corresponds to 85 percent of continental power use.[482] With this mechanism, "the daily cross-border transmission capacity between the various areas is not explicitly auctioned among the market parties, but is implicitly made available via energy transactions on the power exchanges on either side of the border."[483] In this system, electricity prices are set according to the capacity of the elements in the network. Three conditions are essential for the coupling mechanism to function properly. First is a common algorithm that determines the day-ahead prices;[484] second is a healthy and sustainable operation of the integrated system; and the third is transparency and accountability.[485] By the end of

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[481] The market coupling began between Netherlands, Belgium and France. See: Yves Langer, "About Market Coupling," *Belpex*, 2016, available at: https://www.belpex.be/services/market-coupling/about-market-coupling/ (accessed 14 December 2016).

[482] Swissgrid, "Market Coupling: Technical conditions for coupling have been created," *Swissgrid*, 2016, available at: https://www.swissgrid.ch/swissgrid/en/home/reliability/power_market/market_coupling.html (accessed 16 December 2016); Rüdiger Kiesel & Michael Kusterman, "Structural Models for Coupled Electricity Markets," *Journal of Commodity Markets*, vol. 3, no. 1, 2016, p.17.

[483] Yves Langer, "About Market Coupling," *Belpex*, 2016, available at: https://www.belpex.be/services/market-coupling/about-market-coupling/ (accessed 14 December 2016).

[484] The algorithm in EU is called Euphemia. See: European Power Exchange, *Euphemia Public Description*, European Power Exchange, 2016, available at: https://www.epexspot.com/document/36580/Euphemia%20Public%20Description%20-%20December%202016.

[485] Currently, the following countries are included in the coupling mechanism: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the UK. See: European Power Exchange, "PCR: Price Coupling of Regions," *EPEX*

2014, market coupling level increased to 86 percent from 60 percent in 2010.[486] More specifically, the group of countries including Germany, Netherlands, France, Luxemburg, Belgium, Austria, and Switzerland is a net electricity exporter in Europe. This could be possible by cheap power generation.[487]

Globally, most of the single bilateral electricity trade takes place in North America between the US and Canada. The US, the largest economy in the world, is a center of gravity for energy demand. About one-fourth of the global economy is represented by the US.[488] Although energy intensity, defined as the amount of energy used for a unit of GDP produced in an economy, has declined globally,[489] energy demand from the US seems to remain high. On the other hand, electricity generation is considerably high in the US. With a total of 4.3 thousand TWh of electricity generation, it ranks second after China among the top electricity generators, and it ranked first well until 2010. Actually, China produces one quarter of the world's total electricity, while the US generates 18 percent as of 2015. Its neighbors, Canada and Mexico produced 670.7 and 311.1 TWh, respectively in the same year.[490] China is the largest economy, and by far the largest electricity producer in Asia. In 2015, it ranked first with a total of 5.84 thousand TWh of generated electricity, an amount about 36 percent higher than the US, the second largest electricity generating nation

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SPOT, 2016, available at: https://www.epexspot.com/en/market-coupling/pcr (accessed 15 December 2016).

[486] David Newbery, Goran Strbac & Ivan Viehoff, "The Benefits of Integrating European Electricity Markets," *Energy Policy*, vol. 94, 2016, p.253. The authors list a number of benefits of market coupling in Europe.

[487] European Commission, *Quarterly Report on European Electricity Markets*, Directorate-General for Energy, 2016, p.20.

[488] Alex Gray, "The world's 10 biggest economies in 2017," *World Economic Forum*, 2017, available at: https://www.weforum.org/agenda/2017/03/worlds-biggest-economies-in-2017/ (accessed 11 October 2017).

[489] US Energy Information Administration, *International Energy Outlook*, EIA, 2017, available at: https://www.eia.gov/outlooks/ieo/pdf/0484(2017).pdf (accessed 11 October 2017), pp.27-30.

[490] International Energy Agency, "IEA Atlas of Energy," *IEA Statistics*, 2015, available at: http://energyatlas.iea.org/#!/tellmap/-1118783123/1 (accessed 11 October 2017).

in the world.[491] In 2016, China's generation rose to 6,015 TWh, and the consumption was 5,219 TWh.[492] In the same year, China exported 18 TWh of electricity.[493]

3.4.2. Benefits of integration

In the literature, there is some focus on the benefits of integrated electricity grids and electricity markets. Some of the basic economic and technical benefits are summarized here. First, a reduction in the operation costs can be achieved through integration. Also, a balanced system can be assured in cases of peak loads. An integrated system, therefore, reduces the costs of making separate investments for isolated peak demand centers.[494] In addition, integrated electricity markets make fluctuations in electricity demand "smoother," in other words, reducing volatility.[495] Charpentier and Schenk adds the factor of "emergency support" to the list of benefits.[496] Diversifying the sources of electricity, or pooling of resources, through system integration is also an important aspect of emergency supply. Varying

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[491] International Energy Agency, "IEA Atlas of Energy," *IEA Statistics*, 2015, available at: http://energyatlas.iea.org/#!/tellmap/-1118783123/1 (accessed 11 October 2017).

[492] Enerdata, "Electricity Production," *Global Energy Statistical Yearbook*, 2016, available at: https://yearbook.enerdata.net/electricity/world-electricity-production-statistics.html (accessed 12 October 2017); Enerdata, "Eelctricity Consumption," *Global Statistical Yearbook*, 2016, available at: https://yearbook.enerdata.net/electricity/electricity-domestic-consumption-data.html (accessed 12 October 2017).

[493] Enerdata, "Electricity Trade," *Global Energy Statistical Yearbook*, 2016, available at: https://yearbook.enerdata.net/electricity/electricity-balance-trade.html (accessed 12 October 2017).

[494] Global Sustainable Electricity Partnership, *Guidelines for the Pooling of Resources and the Interconnection of Electric Power Systems (RECI)*, E7 Network of Expertise for the Global Environment, 2000, p.5. See also: Manuel Baritaud & Dennis Volk, *Seamless Power Markets: Regional Integration of Electricity Markets in IEA Member Countries*, International Energy Agency, 2014, pp.15-18; Pierre-Olivier Pineau, *Integrating Electricity Sectors in Canada: Good for the Environment and for the Economy*, The Federal Idea, 2012, p.5.

[495] Manuel Baritaud & Dennis Volk, *Seamless Power Markets: Regional Integration of Electricity Markets in IEA Member Countries*, International Energy Agency, 2014, p.17; Richard Pierce, Michael Trebilcock & Evan Thomas, "Beyond Gridlock: The Case for Greater Integration of Regional Electricity Markets," *C.D. Howe Institute Commentary*, vol. 228, 2006, p.3.

[496] J. Charpentier & K Schenk, International Power Interconnections: Moving from electricity exchange to competitive trade, The World Bank, 1995, p.1.

sources, such as hydro, nuclear, solar, etc. can be combined to foster energy security from supply side.[497] Many authors also stressed increased efficiency in electricity generation[498] and an improvement in the quality of electricity services received by the final consumers, as well as adding potential environmental and social benefits,[499] from mitigating the impact of the climate change to supplying sustainable and secure energy to all the people in need.[500]

In the case of North America, Canada has a considerable hydropower potential while the US has coal, nuclear and gas plants. In Central Asia, Uzbekistan has enough fossil fuels to generate electricity while Kyrgyzstan and Tajikistan depend on hydropower. Pooling contributes to reliability and stability of electricity systems. Also, it may help reducing the need for additional investment for increasing generating capacity since an increase in demand can be supplied by the interconnected generators.[501]

In Europe, according to Newbery et al, "short-term trading and balancing" has the potential of generating 3.9 billion euros benefits annually. This corresponds to more

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[497] Manuel Baritaud & Dennis Volk, *Seamless Power Markets: Regional Integration of Electricity Markets in IEA Member Countries*, International Energy Agency, 2014, p.17; Francisco Burgos, *Regional electricity cooperation and integration in the Americas: Potential environmental, social and economic benefits*, Organization of the American States, 2007, pp.11-13.

[498] Richard Pierce, Michael Trebilcock & Evan Thomas, "Beyond Gridlock: The Case for Greater Integration of Regional Electricity Markets," *C.D. Howe Institute Commentary*, vol. 228, 2006, p.1.

[499] Francisco Burgos, Regional electricity cooperation and integration in the Americas: Potential environmental, social and economic benefits, Organization of the American States, 2007.

[500] International Electrotechnical Commission, *Global Energy Interconnection*, International Electrotechnical Commission, 2017, available at: http://www.iec.ch/whitepaper/pdf/iecWP-globalenergyinterconnection.pdf (accessed 10 October 2017), p.17.

[501] Pierre-Olivier Pineau, *Integrating Electricity Sectors in Canada: Good for the Environment and for the Economy*, The Federal Idea, 2012, p.5.

than 100 percent of gains from electricity exchange over interconnectors.[502] In recent years, thanks to the integration of electricity markets with market coupling, prices of electricity fell across Europe.[503] Kiesel and Kusterman focus on two features of coupled electricity markets in the case of Europe. First, they show that coupled markets reduce futures prices in all involved markets. If interconnector capacity is increased, prices converge in due course. If the interconnector capacity is limited, this would increase the volatility in the market prices.[504]

Electricity experts and most scholars writing on integration issues recommend reserve and resource pooling, including pooling of expertise and electricity generation across regions. The means for doing this is integrating the electricity systems. The E7 Group acknowledges that the prerequisite for regional electricity systems integration is a political will among nations. For the countries in a river basin, the planning and functioning of the HPPs and reservoirs should be coordinated. Also, water use would be another issue that must be agreed upon between upstream and downstream countries.[505] This relationship between politics and energy is among the major topics discussed in this study.

In terms of hydroelectricity, integration has some specific benefits. First of all, building of a HPPs is usually costly and complicated but the operation costs are relatively low. This means that economies of scale contribute to the reduction of marginal costs during the functioning of the HPP. In order economies of scale to

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502 David Newbery, Goran Strbac & Ivan Viehoff, "The Benefits of Integrating European Electricity Markets," *Energy Policy*, vol. 94, 2016, p.261.

503 Other possible reason may be an overcapacity in Europe in terms of electricity generation. See: ACER/CEER, *Annual Report on the Results of Monitoring the Internal Electricity Markets in 2015*, ACER/CEER, 2016, p.9.

504 Rüdiger Kiesel & Michael Kusterman, "Structural Models for Coupled Electricity Markets," *Journal of Commodity Markets*, vol. 3, no. 1, 2016, p.36.

505 Global Sustainable Electricity Partnership, *Guidelines for the Pooling of Resources and the Interconnection of Electric Power Systems (RECI)*, E7 Network of Expertise for the Global Environment, 2000, see the guidelines document. See also: J. Charpentier & K Schenk, *International Power Interconnections: Moving from electricity exchange to competitive trade*, The World Bank, 1995, p.2.

help reducing costs, the HPP must operate at maximum capacity as soon as possible. For this to be achieved, a stable demand must be in place. Interconnecting a HPP to various demand centers would increase demand and reduce the time in which a HPP works in overcapacity. Second, HPPs are highly dependent on the fluctuations of water flow during the season and between wet and dry seasons. If a HPP works in integrated mode, low-level generation of dry seasons may be compensated by other generators in the network. This also means that the load in transmission lines is lower in dry seasons or dry periods of the year and the low-load lines may be used for other purposes during dry seasons. Finally, in some regions, power systems may work as complementary systems, depending on geography, economy and peak demand. This is the case for South America,[506] as well as for Central Asia, which would be explored in this study.

3.4.3. Measuring energy integration

In 2004, Pineau et al. developed a continuum to measure the integration of electricity sectors between political entities. This continuum assesses the infrastructural, regulatory and commercial integration. The indicators of international infrastructure integration are the physical capacity of transboundary transmission lines and "the ratio of each country's share of cross-border capabilities over transmission capacity;" the indicators of international commercial integration are import and export data of electricity and the ratio of each country's export and import capacity over its production capacity; and the indicators of regulatory integration are "the degree of coordination among national and sub-national regulatory bodies and the main role such regulatory bodies play in regulating international electricity market integration."[507]

[506] Global Sustainable Electricity Partnership, *Guidelines for the Pooling of Resources and the Interconnection of Electric Power Systems (RECI)*, E7 Network of Expertise for the Global Environment, 2000, pp.10-11.

[507] Pierre-Olivier Pineau, Anil Hira & Karl Froschauer, "Measuring International Electricity Integration: A Comparative Study of the Power Systems under the Nordic Council, MERCOSUR, and NAFTA," *Energy Policy*, vol. 32, 2004, pp.1457-58.

According to these indicators, the authors compare three regions, the North European countries of Denmark, Norway, Sweden, Iceland and Finland; North America including Canada, the US and Mexico; and the Southern Common Market (Mercado Común del Sur - *MERCOSUR*) countries including Argentina, Brazil, Paraguay and Uruguay. The authors expected that the integration in North America would be relatively high, yet their initial assumptions proved to be incorrect based on various factors that will be analyzed in this study. The Nordic countries, on the other hand, seemed to have an almost fully-integrated electricity integration.[508] These indicators can be employed to measure the level of integration in other regions of the world. Pineau et al. base their analysis on comparative advantages and argue that a significant advantage of transnational electricity trade and integration of electricity markets is that the countries in an integrated system can benefit from the various sources of energy, as well as various times of demand during the day across neighboring countries.[509] One should add to this the seasonal difference in peak demands as well (the example of Central Asia).

Charpentier and Schenk focused in 1995 on two methods, one being the tight pool, and another the loose pool. While tight pool systems have a centralized dispatch center, in loose pools, each company has a separate dispatch center. The authors argue that at international integrated systems, tight pool is not applicable and "a common technical dispatch center seems utopian."[510] The Central Asian Power System with the dispatch center in Tashkent is one of the examples for a common dispatch center in an international system. On the other hand, as discussed in this

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[508] Pierre-Olivier Pineau, Anil Hira & Karl Froschauer, "Measuring International Electricity Integration: A Comparative Study of the Power Systems under the Nordic Council, MERCOSUR, and NAFTA," *Energy Policy*, vol. 32, 2004, p.1473.

[509] Pierre-Olivier Pineau, Anil Hira & Karl Froschauer, "Measuring International Electricity Integration: A Comparative Study of the Power Systems under the Nordic Council, MERCOSUR, and NAFTA," *Energy Policy*, vol. 32, 2004, p.1459.

[510] J. Charpentier & K Schenk, International Power Interconnections: Moving from electricity exchange to competitive trade, The World Bank, 1995, p.3.

study, the reliability and sustainability of this system has long been under severe discussion.[511] In a 2012 report, Pineau provided another version of the abovementioned continuum and defined four levels of integration, including the tight and loose pool systems: physical interconnection, loose power pool, tight power pool, competitive electricity market. In the first level, physical interconnection, the grids are interconnected but there is no or very limited interaction between the connected regional grids. All connected regions have their own regulation and planning. In loose pools, there is a certain level of coordination of planning and production, yet regulations among regions are still independent. In contrast, in tight pools, regulations are common and the systems operate according a centralized planning center. Finally, in competitive electricity markets, in addition to all properties of tight pools, planning, prices and all commercial decisions were left to market forces and the rules of fair and regulated competition.[512] One example for the first level physical interconnection is provided by Pineau with a 5,150-megawatt connection between Quebec and Labrador. The interconnection transfers 30 TWh of electricity annually between the regions according to the contract. Beyond this, there is no common regulation or common planning and pricing.[513] An example for the tight power pool is provided in this study, the Central Asian Power System, with its centrally planned and operated system located in Tashkent.

Billette de Villemeur and Pineau focus on institutions. Market integration and deregulation should be together, in order integration to benefit customers in terms of prices. In the US or Canada, in some states, prices are regulated, while in the neighboring states prices may be deregulated. The authors show that this price differences

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[511] J. Charpentier & K Schenk, International Power Interconnections: Moving from electricity exchange to competitive trade, The World Bank, 1995, p.3.

[512] Pierre-Olivier Pineau, *Integrating Electricity Sectors in Canada: Good for the Environment and for the Economy*, The Federal Idea, 2012, p.7

[513] Pierre-Olivier Pineau, *Integrating Electricity Sectors in Canada: Good for the Environment and for the Economy*, The Federal Idea, 2012, p.7

in the integrated markets result with inefficiencies. Often, the generators in the regulated price region aspire to sell electricity to deregulated regions with higher prices.[514] In a similar vein, Kiesel and Kusterman focus on the rule that electricity flows from where prices are lower to where prices are higher. This, in open and integrated markets, would result in the converging of prices in the course of time.[515]

3.5. Conclusion

Water-related issues are often politicized,[516] and the level of politicization increases in water-related energy topics, especially in hydroelectricity generation in shared river basins. Some researchers argue that water issues cannot be understood unless the local and international politics is fully and adequately understood.[517] On the other hand, the water question is highly interconnected with how one culturally, historically, or religiously comprehends water or a river in this context. A river is sometimes a border, a source of freshwater for domestic and agricultural use, a source of energy, a means of transport, or simply, a subject of politics, upon which different actors strive to exert power.[518] This fact changes the perception whether a river is subject to conflict or cooperation, or a scarce resource to be exploited or managed, or a part of the environment that must be protected. This is closely related to the point that water politics brings some properties of water to the political science literature. Freshwater, principally in the form of a river, is a resource that must

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[514] Etienne Billette de Villemeur & Pierre-Olivier Pineau, "Regulation and Electricity Market Integration: When Trade Introduces Inefficiencies," *Energy Economics*, vol. 34, no. 2, 2012, p.526.

[515] Rüdiger Kiesel & Michael Kusterman, "Structural Models for Coupled Electricity Markets," *Journal of Commodity Markets*, vol. 3, no. 1, 2016, p.17.

[516] Jeroen Warner & Kai Wegerich, "Is Water Politics? Towards International Water Relations," in K. Wegerich & J. Warner, eds. *The Politics of Water: A Survey* 1st ed., 2010, p.3.

[517] Jeroen Warner & Mark Zeitoun, "International Relations Theory and Water Do Mix: A Response to Furlong's Troubled Waters, Hydro-Hegemony and International Water Relations," *Political Geography*, vol. 27, 2008, p.802.

[518] Veronica Strang, *The Meaning of Water* (Oxford: Berg, 2004).

be distributed, either between or within states. Water usually brings those states together that are politically distant and have bilateral political disputes. [519] In other words, water flows through global, regional, national and sub-national economies and binds them together.[520]

Water and water management practices and policies are seen by the governments around the world as primary areas of interest for supporting economic development and growth. In parallel, states have reclaimed wide areas in key transboundary river basins and constructed large dams on major rivers. They established comprehensive bureaucratic mechanisms and have been directly involved in water and hydropower schemes. For addressing the increasing water demand driven by economic and population growth, agricultural and environmental water use, the governments have long endeavored to increase water supply, but more recently, they focus on managing water demand instead of generating new supply. In this respect, virtual water trade has become a special topic on the agenda of both agricultural and water bureaucracies. Virtual water trade may be a viable option for a sustainable water management framework in water-scarce transboundary river basins that may decrease the level of water stress in certain regions.

On the other hand, while most of the freshwater in the world is demanded and withdrawn by agricultural sector, other sectors, such as the hydropower industry, sometimes exclusively demand significant amounts of freshwater, mostly in the storages behind great dams. Examples of this dilemma is observed in key transboundary river basins around the world, some of the most important among which are investigated in the following four chapters. These chapters represent an analysis of such

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[519] Ana Cascão & Mark Zeitoun, "Power, Hegemony and Critical Hydropolitics," in A. Earle, A. Jägerskog & J. Öjendal, eds. *Transboundary Water Management: Principles and Practice*, 2010, pp.29-30.

[520] Anton Earle, Anders Jägerskog & Joakim Öjendal, "Introduction: Setting the Scene for Transboundary Water Management Approaches," in A. Earle, A. Jägerskog & J. Öjendal, eds. *Transboundary Water Management: Principles and Practice*, 2010, p.1.

cases on local (state) level, where the hydropolitical relations are in a close and dialectical relationship with economics and politics.

CHAPTER IV

THE UNITED STATES

> The economic greatness of the United States is the fruit of a policy of peaceful conquest over the resources of a virgin continent.
>
> William E. Smythe, 1905[521]

4.1. Introduction

Some of the most prominent hydraulic works in the world have been initiated in North America in the twentieth century. The American engineers have been world famous in constructing extensive irrigation, diversion, hydroelectricity, and reservoir networks, particularly in the extremely arid western regions of the country. Now that the cities on the West Coast are among the most populous[522] and the most prosperous both internationally and nationally,[523] this requires a significant amount of energy in the form of electricity to be consumed along with high volumes of agricultural, domestic and industrial water withdrawals. The US ranks second after China in terms of both electricity production and consumption. But it is the top

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[521] William Smythe, *The Conquest of Arid America* (London: Macmillan Co., 1905), p.3.

[522] California is the most populous state in the US as of 2015 with its 39.1 million inhabitants. See: US Census Bureau, "US and World Population Clock," *United States Census Bureau*, 2015, available at: https://www.census.gov/popclock/ (accessed 17 December 2016).

[523] As of 2016, the GDP of California was estimated at 2.6 trillion US dollars. See: Bureau of Economic Analysis, "Annual Gross Domestic Product (GDP) by State," *Regional Data*, 2017, available at: goo.gl/dp376z (accessed 5 November 2017).

electricity importer in the world by 2016.[524] Most of the imports originate from Canada, and Mexico's share in this high volume of electricity trade has thus far been marginal. Some historical, physical, and economic factors have impacts on this situation as this chapter will investigate.

West America encompasses arid and semi-arid lands and deserts,[525] which are not appropriate for dwelling without human interference on a grand scale, while the eastern part of the continent is more humid and suitable for residing.[526] The following section will analyze the physical characteristics of the US and the river basins it shares with Mexico and Canada.

4.2. Characteristics of the region

The three countries in the North America, Canada, the US and Mexico, share large amounts of water in a high variance of climate and physical hydrological characteristics. The western part of the continent diverges from the rest to a significant degree. Aridity and great rivers are the main characteristics here,[527] and water is an indispensable part of life. The southern past is extremely arid and is under water stress, while the north is richer in terms of water resources and is relatively more humid. This chapter has its focus on the main transboundary river basins in the North America.

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[524] Enerdata, "Electricity Trade," *Global Energy Statistical Yearbook*, 2016, available at: https://yearbook.enerdata.net/electricity/electricity-balance-trade.html (accessed 12 October 2017).

[525] As Smythe notes, "[T]he West is divided from the East by a boundary-line which is not imaginary. […] It is the place where the region of assured rainfall ends and the arid region begins." See: William Smythe, *The Conquest of Arid America* (London: Macmillan Co., 1905), p.21.

[526] See, for example, the works of prominent American researchers, such as: Norris Hundley Jr, *Dividing the Waters: A Century of Controversy between the United States and Mexico* (Berkeley and Los Angeles: University of California Press, 1966); Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Oxford University Press, 1985).

[527] Norris Hundley Jr, *The Great Thirst: Californians and Water—A History* (Berkeley: University of California Press, 2001), pp.1-3.

4.2.1. The US - Canada border

The northern part of the US is both richer and more complex than the south in terms of shared water bodies and river systems. As a consequence, the transboundary water bodies in the north are usually divided in zones in order to study and manage them more systematically. The official transnational commission between the US and Canada, the International Joint Commission (IJC),[528] for instance, divides the shared water bodies in twelve administrative zones, which are, from west to east: the Alaska-Yukon, the Fraser, the Columbia, the St. Mary and Milk, the Poplar and Big Muddy, the Souris, the Red, the Lake of the Woods and Rainy river, the Great Lakes, the Lake Champlain and Richelieu river, the St. John, and the St. Croix river basins.[529] Alternative zoning is possible based on catchment zones. For instance, the Transboundary Waters Assessment Programme defines five main large shared river basins between the two countries. These are, from west to east: the Yukon, the Columbia, the Missouri, the Nelson-Saskatchewan, and the Great Lakes basins, along with the smaller Firth, Alsek, Chilkat, Taku, Stikine, and Whiting basins in the Alaska region, the St. John and the St. Croix river basins on the North Atlantic side, and the Skagit river basin on the Pacific side.[530] On the other hand, the transboundary character of these basins differ from each other, along with their hydropolitical importance on bilateral level.

Between the Columbia river basin and the Great Lakes, the border-crossing rivers are smaller tributaries of much larger river systems such as the Missouri or the Nelson-Saskatchewan river systems. In other words, the St. Mary and Milk and the Poplar rivers are parts of the greater Missouri river catchment area stretching throughout most of the US territory from the northwest to the southeast. The Souris, the Red, the Lake of the Woods and the Rainy river are smaller tributaries that feed

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[528] This intergovernmental body is further discussed in this chapter.

[529] International Joint Commission, "IJC - Protecting Shared Waters," *IJC*, 2017, available at: http://www.ijc.org/en_/ (accessed 15 November 2017).

[530] UNEP/GEF, "Transboundary Waters Assessment Programme - River Basins," *TWAP*, 2016, available at: http://twap-rivers.org/indicators/ (accessed 5 October 2017).

the Lake Winnipeg in Canada like the greater Saskatchewan river does, which flows in west-east direction in Canadian territory. The Lake Champlain drains through the Richelieu river into the St. Lawrence river, a part of the Great Lakes system.

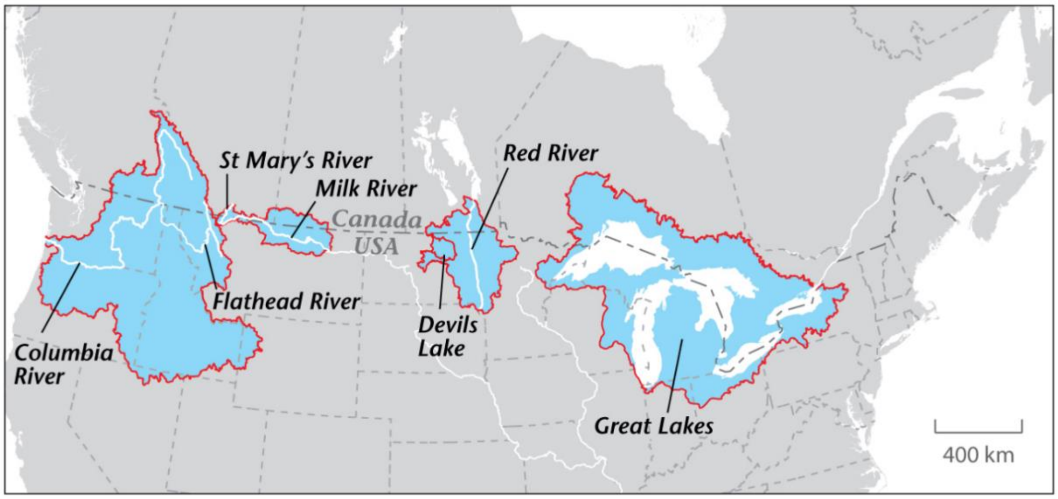

Figure 4.1. Major transboundary watersheds between the US and Canada[531]

In summary, one may list the main river basins that cross the US-Canada border between the Pacific and the Atlantic oceans as follows: the smaller Skagit river basin, the Columbia river basin, the Saskatchewan-Nelson river basin, the interconnected Great Lakes system and the smaller St. Croix, and the St. John river basins in the east.

As Lemarquand notes, the rivers between the two countries establish 2 thousand miles (more than 3,200 kilometers) of the boundary between the countries. There

[531] Eric Leinberger, "Water without Borders?," *Watergovernance.ca*, 2017, available at: http://watergovernance.sites.olt.ubc.ca/files/2012/06/hotspots-04-C-02-012.jpg (accessed 14 November 2017).

are about 300 water bodies shared by the two countries in the form of lakes or rivers.[532] An important proportion of these rivers are in Alaska region, including the great Yukon river. There are plenty of relatively smaller streams in the south of Canada. Among them is the Skagit river in the west, with the headwaters in British Columbia, Canada, and the majority of the mainstream flows towards the Pacific Ocean in the state of Washington of the US. In the east, near the Atlantic Ocean is the 670-kilometer-long Saint John river that partly establishes the US-Canada border and empties into the Bay of Fundy in Canadian territory. Near the same location is the smaller St. Croix river, which establishes the border as well before emptying into the same bay. The Nelson-Saskatchewan river system establishes a huge basin of nearly 1.1 million square kilometers.

As mentioned above, only its smaller tributaries cross the international border and most of the drainage zone remains in Canada. Among these tributaries, the Red river is a major stream that flows in the south-north direction. The Red river has its origins in Minnesota and North Dakota, and empties into Lake Winnipeg before joining the Nelson river from the right. Likewise, the Missouri river basin remains largely in the US territory, the most important transboundary river in the Missouri river system is the Milk river, an upstream tributary of the Missouri from the left. Therefore, for the purpose of this study, the Columbia river system and the Great Lakes are major water bodies with real political and economic transboundary characters.

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[532] David Lemarquand, "Preconditions to Cooperation in Canada–United States Boundary Waters," *Natural Resources Journal*, vol. 26, no. 2, 1986, p.221.

Figure 4.2. Map of the Columbia river basin and the dams[533]

The major shared river basin in the Pacific Northwest is the Columbia river basin. The river mainstream ranks fourth in North America in terms of length, which is more than 1,950 kilometers.[534] Its basin covers about 673 square kilometers. The headwaters of the mainstream Columbia river are in Canada, in British Columbia,

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[533] State of Washington, "Columbia River Facts," *Department of Ecology of the State of Washington*, 2017, available at: http://www.ecy.wa.gov/programs/wr/cwp/cwpfactmap.html (accessed 5 September 2017).

[534] Foundation for Water & Energy Education, "What Makes The Columbia River Basin Unique And How We Benefit," *FWEE*, 2017, available at: http://fwee.org/environment/what-makes-the-columbia-river-basin-unique-and-how-we-benefit/ (accessed 6 September 2017).

and its mouth is in the US, Oregon.[535] To the east and north, the basin is bordered with the Rocky Mountains. In the west, near the Pacific Ocean, the Cascade Mountain Range establishes a geographical barrier in the north-south direction for the basin waters, but the river passes through the range and empties into the ocean. To the south of the Columbia river basin is the largest endorheic basin of North America, the Great Basin, which stretches between the Rocky Mountains, the Sierra Nevada, and the Colorado Plateau.[536] The mainstream of the Columbia river establishes the border between Oregon and Washington and flows west until the Pacific Ocean. The Columbia river is joined by the Snake river from the east, the longest tributary.[537] Canada contributes about one quarter of the total runoff,[538] and the total water withdrawal from the mainstream is about 5.8 cubic kilometers per annum. Among the water users, the Bureau of Reclamation is the largest user responsible for two-thirds of the total withdrawals.[539] It operates more than fifty dams in the region. The Columbia basin rivers contribute about 60-70 percent of total electricity generation in Pacific Northwest region of the US.[540]

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[535] State of Washington, "Columbia River Facts," *Department of Ecology of the State of Washington*, 2017, available at: http://www.ecy.wa.gov/programs/wr/cwp/cwpfactmap.html (accessed 5 September 2017).

[536] Foundation for Water & Energy Education, "What Makes The Columbia River Basin Unique And How We Benefit," *FWEE*, 2017, available at: http://fwee.org/environment/what-makes-the-columbia-river-basin-unique-and-how-we-benefit/ (accessed 6 September 2017).

[537] Other major tributaries are the Kootenay in British Columbia; the Pend Oreille that joins from the east; the Willamette, the Deschutes, and the John Day from the south in Oregon; and the Yakima, the Okanogan, the Spokane, and the Methow rivers that join the mainstream in Washington. See: Bureau of Reclamation, *Secure Water Report, Chapter 4: Columbia River Basin*, US Department of the Interior, 2016, pp.4-1.

[538] Bureau of Reclamation, *Secure Water Report, Chapter 4: Columbia River Basin*, US Department of the Interior, 2016, pp.4-1.

[539] State of Washington, "Columbia River Facts," *Department of Ecology of the State of Washington*, 2017, available at: http://www.ecy.wa.gov/programs/wr/cwp/cwpfactmap.html (accessed 5 September 2017).

[540] Bureau of Reclamation, *Secure Water Report, Chapter 4: Columbia River Basin*, US Department of the Interior, 2016, pp.4-1.

To the east, the Great Lakes system is composed of five big lakes, and the lakes are interconnected with rivers. The lakes in the system discharge their water into the Atlantic Ocean through the Saint Lawrence stream. The major lakes included in the system are Superior, Michigan, Huron, Erie, and Ontario lakes. The water flows from Lake Superior towards Huron and Michigan lakes, and from there towards Erie and Ontario lakes. The latter of the five lakes is located on a lower level than the remaining four, and the water from Lake Erie discharges into Ontario through the Niagara Falls. The Great Lakes basin has a humid continental climate, according to the Köppen-Geiger climate classification.[541]

One may summarize the characteristics of the transboundary river basins in northern border of the US as follows: There are numerous big and small transboundary rivers in the north in a humid climate. The most prominent among the transboundary rivers in the north are the Columbia river basin and the Great Lakes system. In both systems, water scarcity is not a serious problem and the climate is far from aridity.

4.2.2. The US - Mexico border

Turning to the south, the US shares two large river basins and a small basin with its southern neighbor. These are the Rio Grande, the Colorado and the Tijuana river basins. The US is in the upstream position in both the Colorado and the Rio Grande basins (Table 4-1 and Table 4-2).

The Rio Grande has its source in the San Juan Mountains, about 3,800 meters in elevation, in the south of Colorado. It flows through the Rio Grande National Forest towards the San Luis Valley, which is an important spot for irrigated agriculture in the Southern Colorado. The river then flows into the White Rock Canyon in the north of New Mexico and crosses the state from north to south. In New Mexico, the

[541] Markus Kottek, et al., "World Map of the Köppen-Geiger Climate Classification Updated," *Meteorologische Zeitschrift*, vol. 15, no. 3, 2006.

Rio Grande flows through the narrow Albuquerque Valley, where irrigated agriculture is densely practiced. In New Mexico, the water of the river is captured by the reservoir of the Elephant Butte Dam, the largest on the mainstream Rio Grande. Leaving the dam, the water of the river flows through the Mesilla Valley and arrives at El Paso, the boundary crossing between the US and Mexico. From here on, the Rio Grande is called the Rio Bravo in Mexico. El Paso is located at the northern edge of the El Paso-Juarez Valley, through which the Rio Grande flows nearly 150 kilometers. Then, the river makes a bend, known as the Big Bend, towards the north and then again towards the south, reaching to the Rio Grande Valley and finally the Gulf of Mexico. The Valley is a delta of about 13 thousand square kilometers (5,000 square miles) and has a rich alluvial soil, divided between Mexico and the US.[542]

The total length of the Rio Grande is more than 3,000 kilometers, about 2,000 of which establishes the international boundary between the US and Mexico, and some parts of the riverbed may be dry depending on the season of the year.[543] The river is the source of irrigation for more than 8,000 square kilometers (2 million acres) of agricultural land, which are divided almost equally between Mexico and the US.[544] Near its headwaters, the river is joined by small streams of seasonal snowmelt and rainwater from the mountains until it reaches the Grande Reservoir. After the reservoir, the river is joined by tens of small mountain creeks until it reaches the San Luis Valley. In the Valley, a number of tributaries join the mainstream, and much of the water in the tributaries feed the irrigation canals, including the vast Rio Grande Canal system, that divert water from the Rio Grande towards the fertile fields in the San Luis Valley. The major tributary in the northern basin is the Pecos

[542] Norris Hundley Jr, *Dividing the Waters: A Century of Controversy between the United States and Mexico* (Berkeley and Los Angeles: University of California Press, 1966), pp.5-7.

[543] Nicole Carter, Stephen Mulligan & Clare Seelke, *U.S.-Mexican Water Sharing: Background and Recent Developments*, Congressional Research Service, 2017, p.14.

[544] Tim McNeese, *The Rio Grande* (Philadelphia: Chelsea House Publishers, 2005), pp.2-8.

River, which flows parallel to the Rio Grande and joins the mainstream at the northern edge of the Big Bend. In the southeast, the Devils river joins too. From the west, the Mexican side, the Rio Conchos, the Rio Saldado, the Rio Alamo, and the Rio San Juan join the mainstream. From its headwaters to Fort Quitman, Texas, the Rio Grande river basin is known as the Upper Rio Grande basin, which is operated and developed by the US Bureau of Reclamation (USBR) and the US Army Corps of Engineers.[545] The Rio Grande stream dries up before it confluences with the Rio Conchos because of evaporation and heavy agricultural water withdrawals.[546] Therefore, the Rio Grande basin is usually described as two separate basins with two separate rivers.

Another major river basin shared by the US and Mexico is the Colorado river basin, which has 97 percent of its flow in the US in seven states, Arizona, California, Colorado, Nevada, New Mexico, Utah and Wyoming.[547] It is usually divided into two parts, the Upper and the Lower Colorado Basin. The upper basin involves parts of Wyoming, Colorado, New Mexico, Utah, and Arizona, and the lower basin covers portions of Nevada, Arizona, California, Utah, and New Mexico in the US and Baja California and Sonora in Mexico. The division point is Lee Ferry, according to the Colorado River Compact of 1922.[548] It establishes a short part of the US-Mexico border and then discharges into the Gulf of California.

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[545] Marvin Waterstone, "Transboundary Water Resources Mangement in the Upper Rio Grande Basin," in J. Ganoulis, L. Duckstein, P. Literathy & I. Bogardi, eds. *Transboundary Water Resources Mangement: Institutional and Engineering Approaches*, 1994, p.87.

[546] Stratfor, "Water: The Other U.S.-Mexico Border Issue," *Stratfor Worldview*, 2016 (accessed 7 September 2017).

[547] Nicole Carter, Stephen Mulligan & Clare Seelke, *U.S.-Mexican Water Sharing: Background and Recent Developments*, Congressional Research Service, 2017, p.9.

[548] US Department of the Interior, "Drought in the Colorado River Basin," *Department of the Interior*, 2017, available at: https://www.doi.gov/water/owdi.cr.drought/en (accessed 21 August 2017); "Colorado River Compact" 1922, available at: https://www.usbr.gov/lc/region/g1000/pdfiles/crcompct.pdf (accessed 21 August 2017).

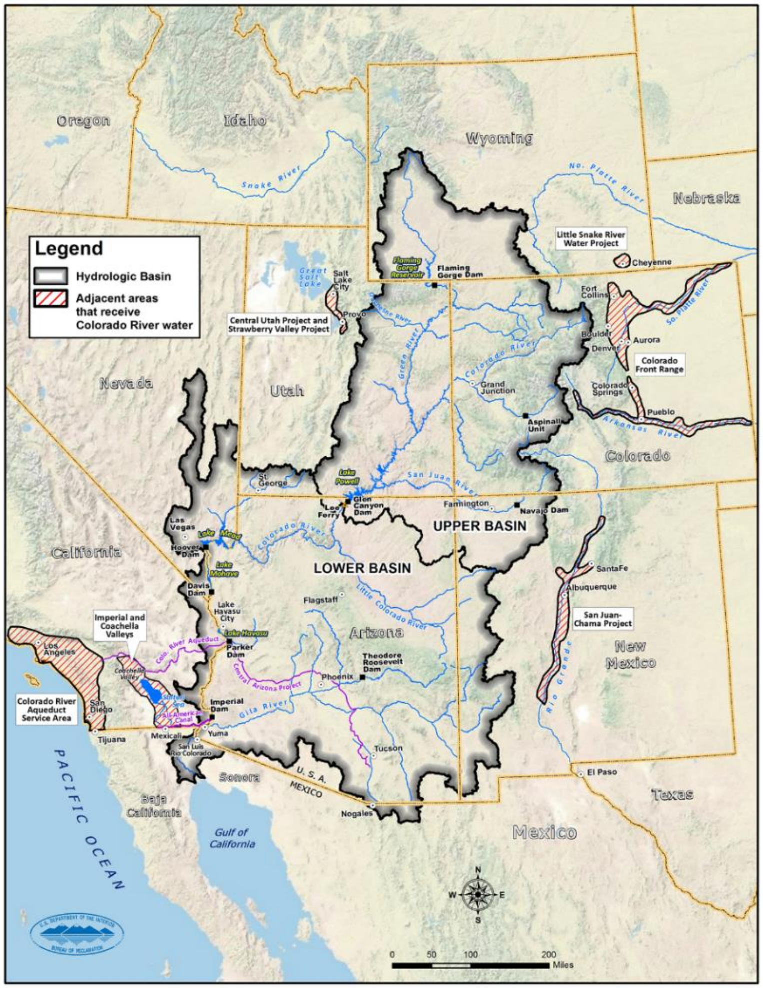

Figure 4.3. Map of the Colorado river basin and river water diversions[549]

The headwaters of the Colorado river are in the southern Rocky Mountains in Colorado at about 3,000 meters above sea level. One of its major tributaries in the northern course, the Green river, has its headwaters further in the north, in Wyoming. The Green and the San Juan rivers join the Colorado in the southeast of Utah, where the Lake Powell is located. Further southeast, the river flows in the deserts of Arizona, joined by the Little Colorado from east, and is trapped near Las Vegas

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[549] US Department of the Interior, "Drought in the Colorado River Basin," *Department of the Interior*, 2017, available at: https://www.doi.gov/water/owdi.cr.drought/en (accessed 21 August 2017).

by a dam that establishes the Lake Mead. Leaving the Lake Mead, the river runs south until the US-Mexico border before reaching the Gulf of California. Arizona, California, Baja California, and Sonora are arid regions that are usually classified as deserts.[550] The total length of the Colorado river is about 2,300 kilometers and the basin of the river covers an area of 625-655 square kilometers (Table 4-1).

The transboundary rivers in the southern part of the US flow in an arid climate and are under significant water stress because of high agricultural, domestic and industrial demand. There are two major river systems, in which the US is in the upstream position and has historically been in need of great amounts of water for supporting dwelling and large-scale irrigated agriculture in the region.

As mentioned, the western part of North America is geographically diverse than the east of the continent. The eastern part of the continent is generally flat and stretches as a huge plain, reaching from the shores of the Atlantic Ocean in the east towards New Mexico, Colorado, Wyoming and Montana states in the US, and the British Columbia in Canada. About in the middle of the continent, there is a vast flat region of steppe, known as the Great Plains, between the western Mississippi river basin and the Rocky Mountains. The Rocky Mountains range stretches from the west of Canada towards the central US, establishing the western frontier of the vast plains in the east of the continent. The Rocky Mountains hosts the headwaters of the Columbia, the Rio Grande, and the Colorado rivers.

[550] Robert Adler, *Restoring Colorado River Ecosystems* (Washington, Covelo, London: Island Press, 2007), p.3.

Table 4-1. Land area of the countries in the Colorado basin[551]

	TFDD	TWAP
Mexico	10.8	6
US	644.4	620
Total	655.2	626

Table 4-2. Land area of the countries in the Rio Grande basin[552]

	TFDD	TWAP
Mexico	316,086	224
The US	339,377	315
Total	655,463	539

Table 4-3. Land area of the countries within the Columbia basin[553]

	TFDD	TWAP
Canada	102,399	103
The US	567,618	550
Total	670,017	653

[551] In thousand square kilometers. The sources in respective order: TFDD: Oregon State University, "Colorado Basin," *Transboundary Freshwater Dispute Database*, 2009, available at: http://gis.nacse.org/tfdd/map/result.php?bcode=CLDO (accessed 22 April 2017); TWAP: UNEP/GEF, "TWAP," *Transboundary Waters Assessment Programme*, 2017, available at: http://www.geftwap.org/twap-project (accessed 18 April 2017).

[552] In thousand square kilometers. The sources in respective order: TFDD: Oregon State University, "Rio Grande (North America) Basin," *Transboundary Freshwater Dispute Database*, 2009, available at: http://gis.nacse.org/tfdd/map/result.php?bcode=RGNA (accessed 21 April 2017); TWAP: UNEP/GEF, "TWAP," *Transboundary Waters Assessment Programme*, 2017, available at: http://www.geftwap.org/twap-project (accessed 18 April 2017).

[553] In thousand square kilometers. The sources in respective order: TFDD: Oregon State University, "Columbia Basin," *Transboundary Freshwater Dispute Database*, 2009, available at: http://gis.nacse.org/tfdd/map/result.php?bcode=CLMB (accessed 20 April 2017); TWAP: UNEP/GEF, "TWAP," *Transboundary Waters Assessment Programme*, 2017, available at: http://www.geftwap.org/twap-project (accessed 18 April 2017).

The US shares not only rivers, but also, it shares some institutions that regulate its transboundary rivers with its neighbors. As the nature and the geography of the river basins change from the south to the north, the content and the focal point of the transboundary institutions and international regulations are also subject to change depending on the general features of the water and economics.

4.2.3. Local institutions and regulations

In the mid-nineteenth century, the most important issue between the US and Mexico was border demarcation. About 2,000 miles (more than 3,200 kilometers) of the boundaries are drawn by the rivers and temporary joint commissions, established with the Guadalupe Hidalgo Treaty of 1848 and the Gadsden Treaty of 1853, played decisive roles.[554] The temporary status of the International Boundary Commission was turned into permanent by the end of the nineteenth century and its name was changed to the International Boundary and Water Commission (IBWC) by 1889.[555]

In 1944, the IBWC was redesigned, and its responsibilities were extended. The Commission now consists of two sections, the US and Mexico sections. Each section involves "a commissioner, two principal engineers, a legal adviser, and a foreign affairs secretary."[556] Among the major duties of the IBWC is the application of the bilateral treaties between the two countries and the coordination of joint projects.[557] According to the 1944 Treaty, known as the "Water Treaty," minor disputes and issues about water between the two countries can be resolved through

[554] IBWC, "History of the International Boundary and Water Commission," *International Boundary and Water Commission, United States Section*, 2017, available at: https://www.ibwc.gov/About_Us/history.html (accessed 1 August 2017).

[555] IBWC, "History of the International Boundary and Water Commission," *International Boundary and Water Commission, United States Section*, 2017, available at: https://www.ibwc.gov/About_Us/history.html (accessed 1 August 2017).

[556] Nicole Carter, Stephen Mulligan & Clare Seelke, *U.S.-Mexican Water Sharing: Background and Recent Developments*, Congressional Research Service, 2017, p.5.

[557] IBWC, "Synopsis of the International Agreements Establishing and Institutionalizing the International Boundary and Water Commission," *International Boundary and Water Commission,*

interpreting the articles of the treaties. The bilaterally agreed and signed interpretations of these treaties are called the minutes. As a rule, these minutes are proposed by the IBWC and subject to approval of the respective governments.[558]

In the 1980s and the 1990s, as the IBWC proved ineffective, the two governments sought alternatives for effective water management in the Rio Grande and the Colorado river basin regions. The agreements supplementary to the North American Free Trade Agreement (NAFTA) was among these, such as the "North American Agreement on Environmental Cooperation"[559] and the "Border Environmental Cooperation Agreement."[560] With the former, the "Commission for Environmental Cooperation (CEC)" was established.[561] Today, the CEC works on a variety of environmental issues, such as climate change, pollution, ecosystems, and green economy.[562]

Recent reports indicate that water pollution in the Rio Grande is on alarming levels.[563] The water quality and other environmental problems were officially

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United States Section, 2017, available at: https://www.ibwc.gov/About_Us/synopsis.html (accessed 1 August 2017).

558 Nicole Carter, Stephen Mulligan & Clare Seelke, *U.S.-Mexican Water Sharing: Background and Recent Developments*, Congressional Research Service, 2017, p.6.

559 "North American Agreement on Environmental Cooperation between the Government of Canada, the Government of the United Mexican States and the Government of the United States of America" 1993,.

560 This agreement is known as the La Paz Agreement. See: "Agreement between the United States of America and the United Mexican States on Cooperation for the Protection and Improvement of the Environment in the Border Area" 1983,.

561 M.I. Gunning, "The Projected Impact of the North American Free Trade Agreement on Transboundary Water Management Between Mexico and the U.S.A.," in J. Ganoulis, L. Duckstein, P. Literathy & I. Bogardi, eds. *Transboundary Water Resources Management: Institutional and Engineering Approaches*, 1994, pp.77-78.

562 Commission for Environmental Cooperation, "Our Work," 2016, available at: http://www.cec.org/our-work (accessed 3 August 2017).

563 Neena Satija, "Despite Efforts, The Rio Grande Is One Dirty Border," *npr*, 2013, available at: http://www.npr.org/2013/10/22/239631549/despite-efforts-rio-grande-river-is-one-dirty-border (accessed 3 August 2017).

acknowledged by the governments of the US, Canada, and Mexico. Some important steps were taken together by the governments of these states to monitor and prevent contamination.[564] In parallel, the CEC was given the objective of reducing trans-boundary pollution. According to the CEC, in 2005, the US and Canada each were accountable for more than 49 percent of total pollutant releases to water, while Mexico contributed less than 1 percent. By 2010, the Canadian pollutant releases increased to 54 percent and the US releases decreased to 46 percent.[565]

Sharing the water of the transboundary rivers between the US and Mexico has historically been a major regional political issue that became subject to bilateral agreements.[566] According to the 1944 Water Treaty mentioned above, below Fort Quitman on the US-Mexico border, Mexico gets at least two-thirds of the water from the six major tributaries of the Rio Grande on the Mexican side. These tributaries are: the Conchos, the San Diego, the San Rodrigo, the Escondido, the Salado, and the Las Vacas. As for the US, it gets all water from the tributaries of the Rio Grande on the US side of the border, and one-third of the water from the Mexican side. According to the agreement, the total water delivery of Mexico to the US should be no less than 350 thousand acre-feet (0.43 cubic kilometers) annually, as an average of five year measurements. If Mexico could not deliver the specified amount, it gets indebted to the US and should pay it to the US in due course.[567] Although agriculture has long been the major user of water in the Rio Grande and

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[564] M.I. Gunning, "The Projected Impact of the North American Free Trade Agreement on Transboundary Water Management Between Mexico and the U.S.A.," in J. Ganoulis, L. Duckstein, P. Literathy & I. Bogardi, eds. *Transboundary Water Resources Management: Institutional and Engineering Approaches*, 1994, p.73.

[565] CEC, *Taking Stock: North American Pollutant Releases and Transfers, Vol. 14*, Commission for Environmental Cooperation, 2014, p.30.

[566] For a comprehensive historical account of water sharing, one may refer to Norris Hundley Jr, *Dividing the Waters: A Century of Controversy between the United States and Mexico* (Berkeley and Los Angeles: University of California Press, 1966).

[567] Nicole Carter, Stephen Mulligan & Clare Seelke, *U.S.-Mexican Water Sharing: Background and Recent Developments*, Congressional Research Service, 2017, pp.7-8.

the Colorado river basins, the 1944 Water Treaty gives priority to domestic and municipal uses of water. Agricultural use ranks second, hydropower production third, industrial withdrawals fourth, navigation fifth, and fisheries ranks sixth, according to the treaty.[568]

With regards to the US-Canada transboundary water relationship, the US has neither a clear upstream nor a definitive downstream position. This is, according to Lemarquand, a major reason why the US and Britain (on behalf of Canada) have signed the Boundary Waters Treaty[569] in 1909 on equal terms and established the International Joint Commission.[570] Specifically, the transboundary Columbia river basin is regulated by the Columbia River Treaty of 1961, ratified in 1964.[571] Accordingly, Canada would construct three dams with a reservoir capacity of about 19.1 cubic kilometers. These facilities are used in coordination with the US government for multiple purposes including flood protection and hydroelectricity generation. Canada has half the share of the electricity generated in the US-side, by the operation of the Canadian facilities. This share is known as the "Canadian Entitlement" and is worth about 300 million US dollars annually.[572] The terms in this

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[568] Nicole Carter, Stephen Mulligan & Clare Seelke, *U.S.-Mexican Water Sharing: Background and Recent Developments*, Congressional Research Service, 2017, p.8.

[569] "Boundary Waters Treaty" 1909, available at: http://www.ijc.org/en_/bwt (accessed 7 September 2017).

[570] David Lemarquand, "Preconditions to Cooperation in Canada–United States Boundary Waters," *Natural Resources Journal*, vol. 26, no. 2, 1986, p.223; International Joint Commission, "IJC - Protecting Shared Waters," *IJC*, 2017, available at: http://www.ijc.org/en_/ (accessed 15 November 2017).

[571] International Water Law Project, "Treaty relating to cooperative development of the water resources of the Columbia River Basin (with Annexes)," n.d., available at: http://internationalwaterlaw.org/documents/regionaldocs/columbia_river1961.html (accessed 7 September 2017).

[572] "Columbia River Treaty," *Columbia River Inter-Tribal Fish Commission*, 2017, available at: http://www.critfc.org/tribal-treaty-fishing-rights/policy-support/columbia-river-treaty/ (accessed 29 August 2017).

treaty have a lifespan of 60 years, which means that by 2024, the parties can terminate the treaty by informing the other party ten years in advance. As of 2014, therefore, the tribes within the basin involved in the issue to protect their cultural heritage and resources.[573]

4.3. Water development projects in the US

In the arid regions of North America, water has been subject to dispute internally in the US between "communities, states, and the federal government," as well as internationally between the US and Canada, especially between the US and Mexico.[574] Recently, the most relevant topic with regards to hydropolitics in North America has been the drought that has been prevailing for more than a decade, and the adverse impacts of climate change, in the form of extreme weather conditions.[575] In 2016, the US President Barrack Obama tried to finalize an agreement with Mexico on water sharing during drought years. The inauguration of Donald Trump raised concerns not only about the future of Paris Agreement, but also about the future of the US-Mexico negotiations on the bilateral agreement.[576] In the following paragraphs, most prominent and politicized domestic and regional water issues will be discussed.

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[573] "Columbia River Treaty," *Columbia River Inter-Tribal Fish Commission*, 2017, available at: http://www.critfc.org/tribal-treaty-fishing-rights/policy-support/columbia-river-treaty/ (accessed 29 August 2017). See also: US Energy Information Administration, "The Columbia River Basin provides more than 40% of total U.S. hydroelectric generation," *EIA*, 2017, available at: https://www.eia.gov/todayinenergy/detail.php?id=16891 (accessed 14 February 2018).

[574] Norris Hundley Jr, *The Great Thirst: Californians and Water—A History* (Berkeley: University of California Press, 2001), pp.3-4.

[575] Ian James, "Big unfinished business for Trump: Colorado River deals, the shrinking Salton Sea," *Desert Sun*, 2017, available at: http://www.desertsun.com/story/news/environment/2017/01/20/big-unfinished-business-trump-colorado-river-deals-shrinking-salton-sea/96846680/ (accessed 2 August 2017).

[576] Daniel Rothberg, "Trump, Western storms cast uncertainty on Colorado River," *Las Vegas Sun*, 2017, available at: https://lasvegassun.com/news/2017/apr/03/trump-western-storms-cast-uncertainty-on-colorado/ (accessed 2 August 2017).

4.3.1. Background

In the arid regions, water has always been valuable and waterworks have been of great importance. Nearly half of North America is arid and one of the earliest irrigation practices in the arid regions of the continent was near today's Owens Valley applied by the Paiute people, who erected simple dams and dug irrigation canals,[577] which were administered by the elected public agents.[578] In the Sonoran Desert, about 300 kilometers northeast of today's Imperial Valley, an irrigation technique what is today known as the floodplain irrigation was applied[579] and, around 600-800 AD, the Hohokam people, who settled in what is today Arizona, around Gila and the Salt River, established extensive irrigation networks.[580] In the tenth century, another native society, which was mistakenly named Anasazi, was conducting sophisticated irrigation in Southwest America and constructed dams and reservoirs.[581] These people were among the first Americans growing cotton,[582] which gradually became one of the major crops harvested in West America especially after the mid-

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[577] Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Oxford University Press, 1985), p.32.

[578] Harry Lawton, Philip Wilke, Mary DeDecker & William Mason, "Agriculture Among the Paiute of Owens Valley," *The Journal of California Anthropology*, vol. 3, no. 1, 1976, p.18; Harry Williams, Harry Williams, Bishop Paiute Tribal Member, 2013.

[579] In this method, the flooding silty river water comes with a high velocity over the soil. The speed of this flood stream is decreased with the bushes planted by the people. These artificially planted bushes also help water spreading onto the ground in a slow manner. See: Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Oxford University Press, 1985), p.33.

[580] Thomas Cech, *Principles of Water Resources: History, Development, Management* (New York: John Wiley & Sons, 2010), p.9. According to Worster, the largest canal was 30 feet wide, 7 feet deep and 8 miles long. See: Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Oxford University Press, 1985), p.34.

[581] Thomas Cech, *Principles of Water Resources: History, Development, Management* (New York: John Wiley & Sons, 2010), p.10.

[582] Matthew Markowitz, "The Ancient Pueblo (the Anasazi)," *ICE Case Studies*, 2003, available at: http://www1.american.edu/ted/ice/anasazi.htm#_ftn4 (accessed 24 November 2016). Cotton was cultivated by the Native Americans, near the Rio Grande, by the time Europeans arrived. See: Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Oxford University Press, 1985), p.75.

nineteenth century. In the southernmost of the US, the Quechan people wisely used the Colorado River floods for irrigation purposes as well.[583]

The early irrigation techniques and knowledge facilitated the first European settlers of America shaping their irrigation plans and development projects. After the arrival of the Europeans, the initiation of mass production in agriculture was a crucial milestone in the water management history of the continent.[584] The Mormons were the pioneers of waterworks among the newly arrived, and it is often argued that the beginning of the modern irrigation technology coincided with the arrival of them to the Great Salt Lake in Utah in 1847. By the beginning of the twentieth century, the Mormons here were already cultivating nearly 2.5 million hectares of land, and their efforts of irrigation became a model for the entire western US.[585] The Homestead Act of 1862, which allowed people to own vast acreages of land in the West if they settled there for more than five years and on the condition that they made developments, such as irrigation or construction, escalated the settlement in the arid

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583 Harry Lawton, Philip Wilke, Mary DeDecker & William Mason, "Agriculture Among the Paiute of Owens Valley," *The Journal of California Anthropology*, vol. 3, no. 1, 1976; Eric Stene, *Yuma Project and Yuma Auxiliary Project*, 1996, pp.2-3; Robert Sauder, *The Yuma Reclamation Project: Irrigation, Indian Allotment, and Settlement Along the Lower Colorado River* (Reno & Las Vegas: University of Nevada Press, 2009), p.24.

584 Donald Worster, *The Wealth of Nature: Environmental History and the Ecological Imagination* (Oxford: Oxford University Press, 1993), p.7; The Forest History Society, "Gifford Pinchot," *U.S. Forest Service History*, 2015, available at: http://www.foresthistory.org/ASPNET/People/Pinchot/Pinchot.aspx (accessed 13 November 2016); Kevin Wehr, *America's Fight over Water: The Environmental and Political Effects of Large-Scale Water Systems* (New York and London: Routledge, 2004), p.19.

585 Robert Sojka, David Bjorneberg & J. Entry, "Irrigation: An Historical Perspective" 2002, p.746. See also: Thomas Cech, *Principles of Water Resources: History, Development, Management* (New York: John Wiley & Sons, 2010), p.10; Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Oxford University Press, 1985), p.77-80; Roger Walker, "The Delta Project: Utah's Successful Carey Act Project," *Water History*, 2016, available at: http://www.waterhistory.org/histories/delta/ (accessed 7 December 2016).

West.[586] The new inhabitants developed the irrigation systems they inherited from the native people.[587]

Similarly, in the further south, which remained under the Spanish rule until the 1820s, the early Spanish settlers of what is today California relied on the labor of natives and their earlier irrigation systems.[588] The residents of California at that time had equal rights on water, along with common responsibilities of maintaining and constructing hydraulic works.[589] This tradition continued well into the twentieth century under the US political rule.[590] After the US gained lands in the south after the Mexican-American War of 1848, they used the irrigation systems of the natives as well.[591]

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[586] Thomas Cech, *Principles of Water Resources: History, Development, Management* (New York: John Wiley & Sons, 2010), p.11.

[587] Harry Lawton, Philip Wilke, Mary DeDecker & William Mason, "Agriculture Among the Paiute of Owens Valley," *The Journal of California Anthropology*, vol. 3, no. 1, 1976, pp.31-32; Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Oxford University Press, 1985), p.172; Thomas Farish, "Chapter XII. Early Pioneers and Settlers," *Arizona University Library*, 1915, available at: http://www.library.arizona.edu/exhibits/swetc/hav2/body.1_div.12.html (accessed 8 December 2016).

[588] As of 1800, in the upper Rio Grande basin, there were 164 canals known as *acequias*. See: Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Oxford University Press, 1985), p.75.

[589] Norris Hundley Jr, *The Great Thirst: Californians and Water—A History* (Berkeley: University of California Press, 2001), p.43.

[590] In 1836, for example, some maintenance was needed for the water system in Los Angeles. The Town Council decreed that "drunken Indians," the number of which had increased at that time, can be arrested and sentenced to compulsory work at the hydraulic sites. See: Norris Hundley Jr, *The Great Thirst: Californians and Water—A History* (Berkeley: University of California Press, 2001), p.63. See also: Water and Power Associates, "Zanja Madre - LA's Original Aqueduct," *Water and Power Associates*, 2016, available at: http://waterandpower.org/museum/Zanja%20Madre%20(Original%20LA%20Aqueduct).html (accessed 9 November 2016).

[591] Eric Stene, *Yuma Project and Yuma Auxiliary Project*, 1996, p.3; National Park Service, "Owens Valley Paiute," *National Park Service*, 2016, available at: https://www.nps.gov/manz/learn/historyculture/owens-valley-paiute.htm (accessed 9 November 2016).

One of the aims of the US federal government was increasing the number of new settlements in the West, which was not a simple task. The famous head of the US Geographical Survey, who was commissioned in 1878 by the US Congress to survey the western part of the American continent, once observed that "[t]he [American] West is an arid land, hostile to farming, and will never be settled, opening its resources to America, unless the Federal Government dams the rivers to store winter and spring run-off in reservoirs."[592] The survey headed by John Wesley Powell[593] concluded that despite aridity, there was a great interest in the irrigation potential in the West.[594] Based on this potential, the federal government facilitated settling in these vast, empty, and fertile lands with some further legal arrangements. The Desert Land Act of 1877 granted public land to individuals who brought water to unirrigated lands in the West. In 1887, the Irrigation District Act regulated the irrigation and water management activities. With this law, a group of farmers in a region may apply to the state to set their lands as irrigation districts. If approved by two-thirds of the settlers in the area, the irrigation district is established, in which an elected officer is given broad responsibilities for irrigation developments and water allocation. These officers decide the building of canals, and they had the right of bargaining private water rights in the area on behalf of the district. After the

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[592] Words of John Wesley Powell in 1869. Cited in Robert Morgan, *Water and the Land: A History of American Irrigation* (Fairfax, Virginia: Adams Publishing, 1993), p.53.

[593] John Powell, *Report on the Lands of the Arid Region of the United States with a more Detailed Account of the Lands of Utah*, 1879. John Wesley Powell was the uncle of Arthur Powell Davis. Robert Sauder, *The Yuma Reclamation Project: Irrigation, Indian Allotment, and Settlement Along the Lower Colorado River* (Reno & Las Vegas: University of Nevada Press, 2009), p.59; Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Oxford University Press, 1985), p.172. For his bio, see: Mary Rabbitt, "John Wesley Powell: Pioneer Statesman of Federal Science," in M.C. Rabbitt, E.D. McKee, C.B. Hunt & L.B. Leopold *Colorado River Region and John Wesley Powell*, 1969. Wehr argues that Powell was the father of Davis. Kevin Wehr, *America's Fight over Water: The Environmental and Political Effects of Large-Scale Water Systems* (New York and London: Routledge, 2004), p.59.

[594] John Powell, Report on the Lands of the Arid Region of the United States with a more Detailed Account of the Lands of Utah, 1879, p.xi.

passage of this law, the irrigated lands in California increased.[595] The establishment of some key institutions,[596] such as the US Reclamation Service after the passage of the 1902 Reclamation Act, facilitated and escalated the construction of dams, canals, and other large-scale irrigation projects.[597]

The flow of the transboundary Colorado River, estimated at 17 million acre-feet (nearly 21 cubic kilometers) per annum in average by 1919 at Yuma,[598] along with the vast acreages of empty lands in the West, would soon attract large projects backed by the federal government.[599] After the 1902 Reclamation Act, the irrigation projects began to be financed by selling of the public lands in the West.[600] One of the first and significant projects in the twentieth century was the Yuma Project, a part of which was the Laguna Dam on the Colorado River.[601] The dam provided water both to the Gila Valley and the Imperial Valley irrigation projects.[602] In a

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595 Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Oxford University Press, 1985), p.109.

596 Kevin Wehr, America's Fight over Water: The Environmental and Political Effects of Large-Scale Water Systems (New York and London: Routledge, 2004), p.5.

597 Bureau of Reclamation, "Bureau of Reclamation: A Very Brief History," *Reclamation: Managing Water in the West*, 2016a, available at: http://www.usbr.gov/history/borhist.html (accessed 13 November 2016); US Department of Energy, "History of Hydropower," *Energy.gov*, 2016a, available at: https://www.energy.gov/eere/water/history-hydropower (accessed 16 December 2016).

598 According to measurements between 1902 and 1919. See: Elwood Mead, W. Schlecht, C. Grunsky & Porter Preston, *The All-American Canal: Report of the All-American Canal Board*, Department of the Interior, 1920, p.9.

599 For a historical account on early government involvement in water works in the US, see: David McNabb, "Beginnings of Water Management in the U.S," *Water Resource Management*, 2017.

600 Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Oxford University Press, 1985), p.130; Kevin Wehr, *America's Fight over Water: The Environmental and Political Effects of Large-Scale Water Systems* (New York and London: Routledge, 2004), p.37.

601 Eric Stene, *Yuma Project and Yuma Auxiliary Project*, 1996, p.2.

602 Kevin Wehr, *America's Fight over Water: The Environmental and Political Effects of Large-Scale Water Systems* (New York and London: Routledge, 2004), pp.42-43.

short while, further large-scale projects began to be initiated. In 1911, the famous Boulder Dam was proposed by Mark Rose and the project was approved in 1928. The construction began in 1931 and finished in 1936 as the tallest dam of its time.[603] Another important project was the Theodore Roosevelt Dam, in the northeast of what is today Phoenix, on the Salt River. The 10.5 million US-dollar project was completed in 1911, and became the first major project after the Reclamation Act passed. This was another highest dam in the world of its time.[604]

The federal government-backed projects would soon become subject to controversy among the states. Extensive debates between the states of the West, i.e. California, Colorado, Nevada, New Mexico, Utah, Wyoming, and Arizona, took place before the beginning of the construction of the Boulder Dam. These debates were settled with the signing of the Colorado River Compact in 1922, but Arizona was hesitant to sign until the federal government intervened as the Arizonans thought that the distribution of the water was unequal.[605] In 1921, when the Boulder (later renamed Hoover) Dam was proposed, another project was proposed in response, which was the Glen Canyon Dam, for the development of the upper Colorado basin. The main supporter of this latter project was the politicians in Arizona, who thought that the Boulder Dam was against their advantage, as the real upstream owners of the water.[606] As the Boulder project was concluded against the will of the Arizonans, in

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[603] Kevin Wehr, *America's Fight over Water: The Environmental and Political Effects of Large-Scale Water Systems* (New York and London: Routledge, 2004), pp.45-47. The Boulder Dam, later renamed Hoover, one of the mightiest buildings in the world with its 726 feet (more than 220 meters) height. See: Bureau of Reclamation, "Hoover Dam," *Reclamation: Managing Water in the West*, 2015, available at: http://www.usbr.gov/lc/hooverdam/history/essays/biggest.html (accessed 21 November 2016).

[604] Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Oxford University Press, 1985), pp.172-73.

[605] Kevin Wehr, *America's Fight over Water: The Environmental and Political Effects of Large-Scale Water Systems* (New York and London: Routledge, 2004), pp.47-48.

[606] Kevin Wehr, *America's Fight over Water: The Environmental and Political Effects of Large-Scale Water Systems* (New York and London: Routledge, 2004), p.158.

1946, the USBR was conducting surveys at the Glen Canyon and proposed a dam project that finished in 1963.[607] However, it was not enough for Arizona. In 1952, Arizona authorities sued California because of water rights. The case was concluded in 1963 with the victory of Arizona.[608] The court decided that Arizona had rights over 2.8 million acre-feet (3.5 cubic kilometers) of the annual Colorado flow. In turn, Arizona would give 1 million acre-feet of it to the native tribes.[609] Upon this decision, the US Congress had to approve a project for Arizona, the Central Arizona Project, which includes the pumping of 1.2 million acre-feet (1.5 cubic kilometers) of Colorado water in the Havasu reservoir,[610] just downstream of the Hoover and the Parker, to at least 300 kilometers away towards the cities of Phoenix and Tucson in concrete canals through deserts and mountains via long tunnels and pumping stations.

The Reclamation Service was renamed the US Bureau of Reclamation (USBR) in 1923.[611] Based on the ground that some projects did not yield expected results,[612] Arthur Powell Davis was replaced with Elwood Mead (1858-1936)[613] in 1924, who

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607 The Glen Canyon Dam was the second highest dam in the US, after the Hoover Dam. See: US Bureau of Reclamation, "Glen Canyon Unit," *Reclamation*, 2017, available at: https://www.usbr.gov/uc/rm/crsp/gc/ (accessed 17 February 2018).

608 For the full text of the case and the decision of the US Supreme Court, see: US Supreme Court, "Arizona v. California," *Justia*, 2018, available at: https://supreme.justia.com/cases/federal/us/373/546/case.html (accessed 17 February 2018).

609 Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Oxford University Press, 1985), p.275.

610 Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Oxford University Press, 1985), p.275.

611 Bureau of Reclamation, "Bureau of Reclamation: A Very Brief History," *Reclamation: Managing Water in the West*, 2016a, available at: http://www.usbr.gov/history/borhist.html (accessed 13 November 2016).

612 Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Oxford University Press, 1985), pp.178-79.

613 For the bio of Mead, see: James Kluger, *Turning on Water with a Shovel: The Career of Elwood Mead* (New Mexico: University of New Mexico Press, 1992).

would undertake major hydraulic projects in the West, including the Hoover and the Grand Coulee schemes. Mead's term in office coincided with the Great Depression of 1929, and the ambitious projects would meet severe criticism in the following years.[614] In the 1930s, another player, the US Army Corps of Engineers, would involve in the game of water management and dam building. The Corps began the construction of Bonneville Dam on the Columbia River in 1933 and completed it in 1938. Soon, the activities of the Corps and the USBR would coincide and the two bodies would cooperate. For instance, they produced a co-proposal, known as the Pick-Sloan Plan, to develop the Missouri River, which was accepted by Franklin Roosevelt in 1944.[615]

In California, another great project, known as the Central Valley Project, was conducted by the USBR. This began as a local project and became federal in 1935. Being the biggest project in the history of the USBR, the project was to bring electricity and irrigation water to the Central Valley with dams like the Shasta on the Sacramento River, at the northern edge of the valley. The construction of the 180-meter Shasta Dam continued between 1938 and 1944 and when finished, it was the largest HPP of California. Although the main purpose of the Shasta Dam appeared to be electricity production, it is used merely for irrigation with its reservoir feeding two irrigation canals, the Contra Costa and the Delta-Mendota. The longest artificial ditch in the project was the Friant-Kern Canal, being fed by the Friant Dam on the San Joaquin River on Sierra Nevada. There were 11 canals and 40 additional dams proposed for the Central Valley Project, 28 of these dams would also have a HPP installed. The cost for all these would be at least 2 billion US dollars.[616]

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[614] Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Oxford University Press, 1985), p.187.

[615] Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Oxford University Press, 1985), pp.268-69.

[616] Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Oxford University Press, 1985), p.240.

As of 1978, nearly 45.5 million acres (18.4 million hectares) of land were irrigated in the western part of the US. This acreage corresponded to one-tenth of the total irrigated agricultural lands globally, more than one-third of which is in California and Texas. As Worster argues, in terms of scale and revenue generated, the US became "the greatest hydraulic society ever built in history."[617] In parallel, water use levels have been exceedingly high in the US. As compared with the year 1900, water use increased ten times from 40 billion gallons (0.15 cubic kilometers) per day to 393 billion in 1975. In average, an ordinary citizen consumes 1,600 gallons (6,000 liters) of water daily, yet in agricultural states, like Idaho, it may increase up to 21,000 gallons (80,000 liters).[618]

As the water demand increased continuously, water supply continued to decrease during the twentieth century, especially in the Colorado River basin. By 1914, the annual water consumption in the basin was 4.9 million acre-feet while the supply was 22.6 million acre-feet. In the late 1950s and early 1960s, the demand and the supply of water in the basin reached to a balance at about 10-12 million acre-feet. Since the late 1990s, water demand exceeded 15 million acre-feet per year, above the 110-year average natural flow of the Upper Basin (14.8 million acre-feet).[619] The lack of supply was further exacerbated by the droughts in the recent years, the frequency of which has increased in the US since the 2000s. This is estimated to be a consequence of climate change, which is further discussed in this chapter.

[617] Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Oxford University Press, 1985), p.276**.**

[618] Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Oxford University Press, 1985), p.312.

[619] US Department of the Interior, "Drought in the Colorado River Basin," *Department of the Interior*, 2017, available at: https://www.doi.gov/water/owdi.cr.drought/en (accessed 21 August 2017).

4.3.2. Drought in the southern US and transboundary economic activity

The US Southwest is home to California, the US state with the largest economy, population and densest agricultural activity. The agriculture here concentrates in the south, where water is most scarce. Besides, as mentioned above, the southwest of the US has a warm and arid climate that increases the water stress in the region. As Hanak observes, more recently, one of the major priorities of water policy has become mitigating the impacts of the harm on the environment caused by the economic development and using water more efficiently in order to cope with the negative consequences of the climate change on water condition.[620]

Under these circumstances, as demand for water continues to grow, supply side policies become less viable and the importance of demand management approaches grows (see Chapter 3). As investigated in this study, water markets and water pricing are considered among the best options to manage demand in the US. Other soft[621] demand management methods used are the “information campaigns” and “retrofitting properties” by replacing old and inefficient equipment with new and efficient ones.[622] In California, wastewater garden watering is encouraged, and in Texas, rainwater harvesting from the roofs of the buildings is experimented.[623] All these efforts aim at coping with water scarcity augmented by climate change and occasional droughts in the region.

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[620] Ellen Hanak, "A California Postcard: Lessons for a Maturing Water Market," in K. Burnett, R. Howitt, J.A. Roumasset & C.A. Wada, eds. *Routledge Handbook of Water Economics and Institutions*, 2015, p.253.

[621] Kyle Davis, Maria Rulli, Antonio Seveso & Paolo D’Odorico, "Increased food production and reduced water use through optimized crop distribution," *Nature Geoscience*, vol. 10, no. 12, 2017, p.919.

[622] Colin Green, *Handbook of Water Economics: Principles and Practice* (W.Sussex: John Wiley & Sons, 2003), pp.241-45.

[623] Colin Green, *Handbook of Water Economics: Principles and Practice* (W.Sussex: John Wiley & Sons, 2003), pp.247-48.

In California, following years of drought, concerns of enough water storage in the reservoirs were raised in the past (Figure 4.4). As a consequence, in 1991, the Drought Water Bank was established by the government.[624] Early in 1991, serious cutbacks were announced by the state administration.[625] The Bank was active during the drought years 1991, 1992, and 1994 under the responsibility of the California Department of Water Resources.[626] The Department bought water (about one cubic kilometer) principally from the farmers that voluntarily accept to fallow land and from other water users. The water is then resold to the buyers under specific conditions.[627] In the second half of the 1990s and the early 2000s, environmental water purchases by the state agencies dominated the water market. As a share of total water purchases, environmental water purchases increased to 21 percent in California between 1995 and 2002.[628]

The effectiveness of water use and water demand management became the major concerns of policymakers in the 2000s and the 2010s as the negative consequences of the climate change became more obvious.[629] As the US Department of Interior

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[624] Ellen Hanak, "A California Postcard: Lessons for a Maturing Water Market," in K. Burnett, R. Howitt, J.A. Roumasset & C.A. Wada, eds. *Routledge Handbook of Water Economics and Institutions*, 2015, p.254.

[625] California Department of Water Resources, *The 1991 Drought Water Bank*, 1991, available at: http://www.water.ca.gov/waterconditions/docs/10_1991-water_bank.pdf (accessed 21 August 2017).

[626] California Department of Water Resources, *The 1991 Drought Water Bank*, 1991, available at: http://www.water.ca.gov/waterconditions/docs/10_1991-water_bank.pdf (accessed 21 August 2017), p.1.

[627] Ellen Hanak, "A California Postcard: Lessons for a Maturing Water Market," in K. Burnett, R. Howitt, J.A. Roumasset & C.A. Wada, eds. *Routledge Handbook of Water Economics and Institutions*, 2015, p.263.

[628] Ellen Hanak, "A California Postcard: Lessons for a Maturing Water Market," in K. Burnett, R. Howitt, J.A. Roumasset & C.A. Wada, eds. *Routledge Handbook of Water Economics and Institutions*, 2015, p.263.

[629] Samuel Luoma, Clifford Dahm, Michael Healey & Johnnie Moore, "Challenges Facing the Sacramento–San Joaquin Delta: Complex, Chaotic, or Simply Cantankerous?," *San Francisco Estuary and Watershed Science*, vol. 13, no. 3, 2015.

published in its official website, "since 2000, the Colorado River Basin […] has been experiencing a historic, extended drought that has impacted regional water supply and other resources, such as hydropower, recreation, and ecologic services." According to the department, the basin experienced record low levels of water since a century. This has affected the water stored in the reservoirs to a considerable degree (Figure 4.4).[630] Some measures were taken, such as the lining of irrigation canals, increasing efficiency in irrigation systems, and retirement of some lands. In total, in 20 years between 1982 and 2011, about 5.5 cubic kilometers of water was purchased for environmental purposes and more than half a billion US dollars were spent.[631]

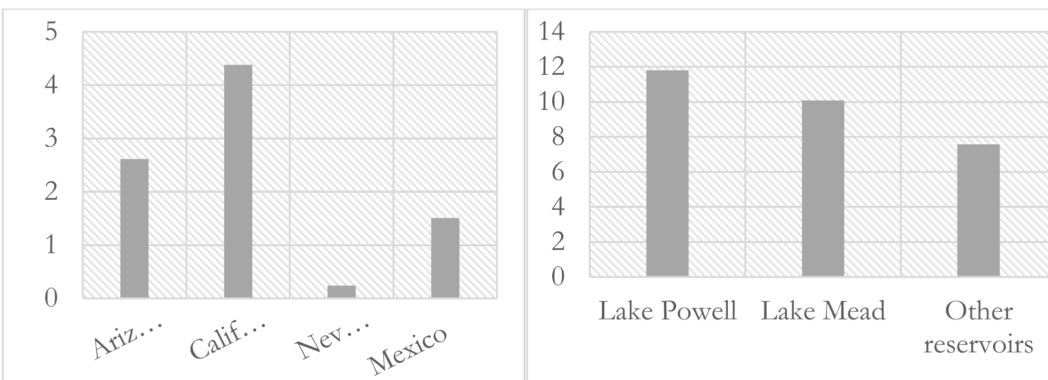

Figure 4.4. Water consumption and live storage in the Colorado reservoirs in 2016[632]

[630] US Department of the Interior, "Drought in the Colorado River Basin," *Department of the Interior*, 2017, available at: https://www.doi.gov/water/owdi.cr.drought/en (accessed 21 August 2017).

[631] Ellen Hanak, "A California Postcard: Lessons for a Maturing Water Market," in K. Burnett, R. Howitt, J.A. Roumasset & C.A. Wada, eds. *Routledge Handbook of Water Economics and Institutions*, 2015, pp.265-69.

[632] In million acre-feet. See: US Bureau of Reclamation, *Colorado River Accounting and Water Use Report: Arizona, California, and Nevada*, Lower Colorado Region, Boulder Canyon

Under the circumstances of aridity, water reallocation has always been an important item on the policy agenda in the southwest of the US. Water is reallocated from the low-value agricultural use to higher-value industrial and domestic uses.[633] As discussed above, this reallocation is achieved through market forces. Especially the selling or leasing of agricultural water rights play a crucial role. In Arizona, New Mexico, and Utah, the offices of State Engineer are responsible for the process of water trade, while in Colorado, water courts are employed for this purpose. As discussed above, in California, the Drought Water Bank undertakes the mission of reallocating water from agricultural to non-agricultural uses.[634] This reallocation caused some decrease in the number of farms in California in the late 1980s and the early 1990s, but in general, there was no significant decrease in total agricultural income. This shows that the reallocation policies increased the effectiveness of water use. Farmers planted higher-value crops and replaced older and inefficient irrigation equipment with more efficient ones.[635]

Operations Office, 2017, available at: https://www.usbr.gov/lc/region/g4000/4200Rpts/DecreeRpt/2016/2016.pdf (accessed 22 August 2017), p.5. Live storage is defined by the USBR as follows: Live storage is "[t]hat part of the total reservoir capacity from which water can be withdrawn by gravity. This capacity is equal to the total capacity less the dead pool capacity. Dead pool is the storage volume in a reservoir that cannot be drained by gravity through a dam's outlet works, spillway, or power plant intake structures and can only be pumped out." See: US Bureau of Reclamation, *Colorado River Accounting and Water Use Report: Arizona, California, and Nevada*, Lower Colorado Region, Boulder Canyon Operations Office, 2017, available at: https://www.usbr.gov/lc/region/g4000/4200Rpts/DecreeRpt/2016/2016.pdf (accessed 22 August 2017), p.3.

[633] Ruth Meinzen-Dick & Claudia Ringler, "Water Reallocation: Drivers, Challenges, Threats, and Solutions for the Poor," *Journal of Human Development and Capabilities*, vol. 9, no. 1, 2008, pp.53-55; Colin Green, *Handbook of Water Wconomics: Principles and Practice* (West Sussex: John Wiley & Sons, 2003), pp.283-85.

[634] Ruth Meinzen-Dick & Claudia Ringler, "Water Reallocation: Drivers, Challenges, Threats, and Solutions for the Poor," *Journal of Human Development and Capabilities*, vol. 9, no. 1, 2008, pp.53-54.

[635] Ruth Meinzen-Dick & Claudia Ringler, "Water Reallocation: Drivers, Challenges, Threats, and Solutions for the Poor," *Journal of Human Development and Capabilities*, vol. 9, no. 1, 2008, p.55.

Despite demand management efforts and regulations supported by the government, one structural fact remains unchanged. On a global level, American people tend to record very high water consumption figures. This also means that the Americans still have margin for further reducing demand.[636] As the droughts continued in the 2010s and their impacts became more severe,[637] the situation became more complicated for the policymakers as they endeavor managing water demand by initiating or further supporting conservation campaigns and movements.[638] The efforts in 2015 and 2016 included municipal water saving by at least 25 percent,[639] "monthly water use reporting, new urban water use targets, reducing system leaks and eliminating clearly wasteful practices, strengthening urban drought contingency plans and improving agricultural water management and drought plans."[640] However, the levels of water scarcity and high water demand reached to a point where these issues may lead to bilateral political disputes in key transboundary rivers, especially in the south.

4.3.3. Transboundary water sharing under climate change

The lack of enough water and rising demand complicates transboundary water management in the Southwest, despite long established rules and interstate institutions

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636 Colin Green, *Handbook of Water Economics: Principles and Practice* (W.Sussex: John Wiley & Sons, 2003), p.240.

637 Henry Fountain, "In California, a Wet Era May Be Ending," *The New York Times*, 2015, available at: https://www.nytimes.com/2015/04/14/science/californias-history-of-drought-repeats.html?mcubz=0&_r=0 (accessed 21 August 2017).

638 Save Our Water, "Save our Water," 2017, available at: www.saveourwater.com (accessed 21 August 2017); Arizona Water Awareness, "Arizona Water Awareness," 2017, available at: http://www.arizonawaterawareness.com/ (accessed 21 August 2017).

639 California Department of Water Resources, "Governor's Drought Declaration, Executive Order B-29-15," *ca.gov*, 2015, available at: https://www.gov.ca.gov/news.php?id=18910 (accessed 21 August 2017).

640 California Department of Water Resources, "Governor's Drought Declaration, Executive Order B-37-16," *ca.gov*, 2016, available at: https://www.gov.ca.gov/news.php?id=19408 (accessed 21 August 2017).

between the US and Mexico, as summarized in the previous section. Currently, there seems to be no real problems of water delivery from the US to Mexico. According to the 2016 report of the USBR, the Lower Colorado River basin states, Arizona, California and Nevada consumed 7.2 million acre-feet (about 8.9 cubic kilometers) of water in 2016 water year. More than 1.5 million acre-feet (about 1.9 cubic kilometers) were delivered to Mexico, as envisaged in the bilateral agreements.[641] But diplomatic and historical disputes may emerge under the conditions of water scarcity augmented by the recent drought conditions.

As the US has a clear advantageous upstream position according to Mexico, the treaties signed between the US and Mexico, as well as the bilateral relations, reflect the dominance of the US side.[642] The theory and ideology behind this pursuit of dominance is closely related to the highly controversial Harmon Doctrine,[643] which is based on “absolute territorial sovereignty” over natural resources, penned in 1895 by Judson Harmon for the purpose of advising the US Department of State with respect to an issue between the US and Mexico regarding the Rio Grande waters.[644]

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[641] US Bureau of Reclamation, *Colorado River Accounting and Water Use Report: Arizona, California, and Nevada*, Lower Colorado Region, Boulder Canyon Operations Office, 2017, available at: https://www.usbr.gov/lc/region/g4000/4200Rpts/DecreeRpt/2016/2016.pdf (accessed 22 August 2017).

[642] David Lemarquand, "Preconditions to Cooperation in Canada–United States Boundary Waters," *Natural Resources Journal*, vol. 26, no. 2, 1986, p.223.

[643] See: Stephen McCaffrey, "The Harmon Doctrine One Hundred Years Later: Buried, not Praised," *Natural Resources Journal*, vol. 36, no. 3, 1996, p.549. The dominant upstream countries tend to adhere to the principles of the Harmon Doctrine, but the more generally accepted principle is based on sharing water resources on more equal basis.

[644] In the end of the nineteenth century, the San Luis Valley irrigation works in the US made parts of the Rio Grande riverbed dry and the Mexican government demanded the amount of water released would be increased to solve the problems stemming from lack of water. See: Stephen McCaffrey, "The Harmon Doctrine One Hundred Years Later: Buried, not Praised," *Natural Resources Journal*, vol. 36, no. 3, 1996, p.551.

Currently, the most important transboundary water question between the US and Mexico is water scarcity. This is valid for both sides. One recent example of disputes emerged during the lining of the All-American Canal, a controversial project completed in 2009.[645] It has been an issue between the two riparians as the US farmers need more water and do not want it to be lost during its travel in the unlined canal, while the Mexican government focus on the process of water infiltration into the sandy soil during its journey in the canal that feeds an important aquifer in Mexicali.[646] The water seeps from the canal to underground and flows across the border towards Mexico, which pumps it from the ground through at least 600 wells to irrigate the Valle de Mexicali.[647] The pumped water also created a habitat for birds.[648] The project of the US government to line the canal caused dispute between the governments of two riparian states.[649] The Minute 242 has some clauses on groundwater pumping. Accordingly, the countries will limit groundwater pumping within five miles to the border to 160,000 acre-feet annually and "[…] consult with each

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645 Imperial Irrigation District, "All-American Canal Lining Project," *IID*, 2017, available at: http://www.iid.com/water/library/all-american-canal-lining-project (accessed 25 December 2017). See also: Eric Stene, *All-American Canal: Boulder Canyon Project*, Bureau of Reclamation, 1995 [2009].

646 Vicente Munguía, *Water Conflict Between the US and Mexico: Lining of the All-American Canal*, UNDP, 2006, pp.1-3.

647 Douglas Hayes, "The All-American Canal Lining Project: A Catalyst For Rational and Comprehensive Groundwater Management on the United States- Mexico Border," *Natural Resources Journal*, vol. 31, no. Fall, 1991, p.805.

648 Osvel Hinojosa-Huerta, Pamela Nagler, Yamilett Carrillo-Guerrero & Enrique Zamora-Hernández, "Andrade Mesa Wetlands of the All-American Canal," *Natural Resources Journal*, vol. 42, 2002, p.900.

649 Douglas Hayes, "The All-American Canal Lining Project: A Catalyst For Rational and Comprehensive Groundwater Management on the United States- Mexico Border," *Natural Resources Journal*, vol. 31, no. Fall, 1991, p.806.

other prior to undertaking any new development of either the surface or the groundwater resources […]"[650] It is understood that the treaty forces the parties to collaborate and cooperate on water issues, either on ground or surface water. Yet, the politicians did not have the will to apply these resolutions and the dispute on groundwater stalled up until the mid-2000s.[651] A Mexican researcher found that the lining of the canal would have significant impact on the Mexican agricultural sector. Accordingly, 121 wells and more than 33 thousand acres (more than 13 thousand hectares) of agricultural zone will be affected, costing 80 million US dollars annually. The main crops on the Mexican side are cotton and wheat, with cotton being the foremost source of income of farmers.[652]

Another problem has been Mexico's failure in meeting its obligations in the Water Treaty. The drought years in the 2010s made Mexico fail to meet its obligations of releasing the necessary amount of water to the US. This increased the political tension between the two countries in recent years.[653] On the other hand, the Mexicans tend to perceive water sharing as a sovereignty issue and an important aspect of

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[650] International Boundary and Water Commission United States and Mexico, *Minute 242: Permanent and Definitive Solution to the International Problem of the Salinity of the Colorado River*, August 30, 1973, p.3.

[651] Stephen Mumme, "Advancing Binational Cooperation in Transboundary Aquifer Management on the U.S. - Mexico Border," *Colorado Journal of International Environmental Law & Policy*, vol. 16, 2005, pp.80-81.

[652] J. Calleros, "The Impact on Mexico of the Lining of the All-American Canal," *Natural Resources Journal*, vol. 31, 1991, pp.831-32.

[653] Jesus Luevano, "Water Dispute Heightens Tensions Between U.S., Mexico (Radio Program)," *npr*, 2013, available at: http://www.npr.org/2013/09/04/218834216/water-dispute-heightens-tensions-between-u-s-mexico (accessed 7 September 2017).

Mexican nationalism.[654] The dependency of Mexico on the transboundary river waters is much higher than the US,[655] and the Mexican government believes that there is an urgent need for a new water agreement between the US and Mexico under the circumstances of severe drought.[656] The drought conditions already led water levels in the transboundary rivers decrease to a significant degree (Figure 4.5).

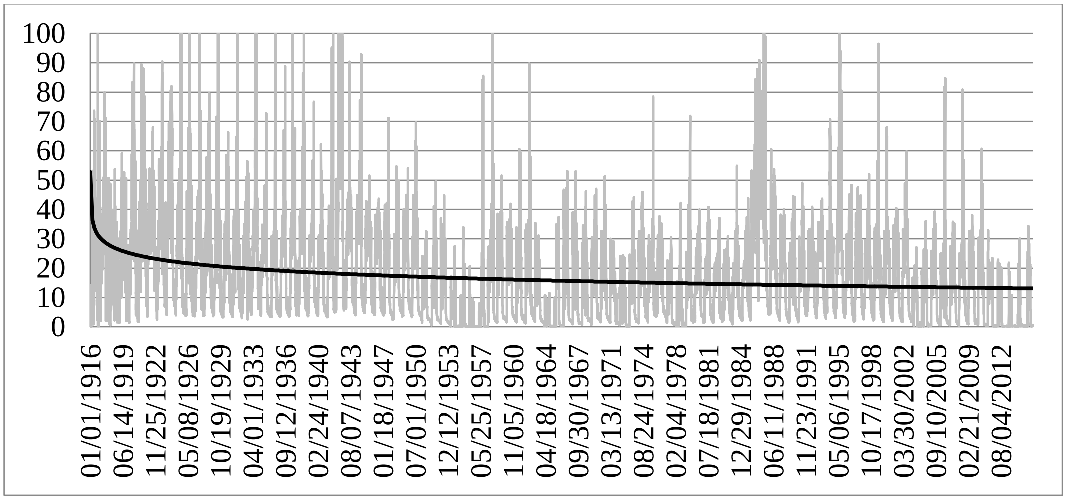

Figure 4.5. Rio Grande flows at El Paso, Texas, in cubic meters per second[657]

[654] Annie Snider, "Trump Win Churns U.S.-Mexico Water Talks," *Politico*, 2016, available at: http://www.politico.com/story/2016/11/colorado-river-mexico-water-sharing-trump-231811 (accessed 7 September 2017).

[655] Stratfor, "Water: The Other U.S.-Mexico Border Issue," *Stratfor Worldview*, 2016 (accessed 7 September 2017).

[656] Annie Snider, "Trump Win Churns U.S.-Mexico Water Talks," *Politico*, 2016, available at: http://www.politico.com/story/2016/11/colorado-river-mexico-water-sharing-trump-231811 (accessed 7 September 2017).

[657] IBWC, "Rio Grande Historical Mean Daily Discharge Data," *International Boundary & Water Commission*, 2017, available at: https://www.ibwc.gov/wad/DDQPASOR.htm (accessed 27 July 2017).

High demand and high scarcity in the southwest has always been an immense problem. As early as in 1946, a report by the US Department of the Interior estimated the total water supply of the Colorado River "in its virgin condition" as 17.72 million acre-feet (21.86 cubic kilometers). This was the amount of water that crossed the international border. According to the 1944 Water Treaty, Mexico should receive a total of 1.5 million acre-feet (1.85 cubic kilometers) of the Colorado River water on an annual basis.[658] On the other hand, the water divisions already made by 1946 in the US left about 9.1 million acre-feet (11.2 cubic kilometers) of that water.[659] By the 1990s, water availability was already a major concern of the basin states. According to estimates, the Rio Grande and the Colorado water use were 40 percent above available water supply.[660] This ceased the Colorado River's reach to the sea since 1998. More recently, in 2014, the US and Mexico governments reached an agreement to release Colorado River water, the "pulse flow," from storages under Minute 319. This means that after a sixteen years of gap, the Colorado water has reached the seawater once again.[661]

As of 2008, it is estimated that the water supply-demand imbalance in the Colorado River basin in the next 50 years would grow to a significant degree.[662] To overcome

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[658] US Department of the Interior, *The Colorado River: A Natural Menace Becomes a National Resource*, The Bureau of Reclamation, 1946, pp.12-13.

[659] US Department of the Interior, *The Colorado River: A Natural Menace Becomes a National Resource*, The Bureau of Reclamation, 1946, p.13. Carter et al. gives the Colorado river flow as 16.8 million acre-feet per year. See: Nicole Carter, Stephen Mulligan & Clare Seelke, *U.S.-Mexican Water Sharing: Background and Recent Developments*, Congressional Research Service, 2017, p.10.

[660] M.I. Gunning, "The Projected Impact of the North American Free Trade Agreement on Transboundary Water Management Between Mexico and the U.S.A.," in J. Ganoulis, L. Duckstein, P. Literathy & I. Bogardi, eds. *Transboundary Water Resources Management: Institutional and Engineering Approaches*, 1994, p.74.

[661] Sandra Postel, "A Sacred Reunion: The Colorado River Returns to the Sea," *Water Currents*, 2014, available at: https://voices.nationalgeographic.org/2014/05/19/a-sacred-reunion-the-colorado-river-returns-to-the-sea/ (accessed 9 September 2017).

[662] US Bureau of Reclamation, *Colorado River Basin Water Supply and Demand Study*, US Department of the Interior, 2012, p.10.

this shortage of future supply, a wide range of options are considered including the construction of desalination facilities, wastewater reuse, water imports, etc.[663] For the Rio Grande basin, similar shortage problems prevail due to severe droughts and the expansion of irrigated agriculture in Mexico in Tamaulipas and Chihuahua.[664] According to the 1906 Agreement, the US has to provide 60 thousand acre-feet (0.074 cubic kilometers) of water to Mexico annually. Since 1939, the water deliveries from the US to Mexico has been in a steady decline. In recent years, due to a severe drought, the deliveries remained on lower levels.[665]

Although the main water-related debate between the US and Mexico has been on sharing the resources of the transboundary river basins, water pollution, salinity, and biodiversity have also been on the agenda as important items.[666] Population growth and industrialization have had negative impacts on the Rio Grande and Colorado River basins, at least since 1965, starting with the industrialization program of the Mexican government. In the 1990s, water pollution problems emerged as major issues in the transboundary river basins between the US and Mexico.[667] Up

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[663] US Bureau of Reclamation, *Colorado River Basin Water Supply and Demand Study*, US Department of the Interior, 2012, pp.13-14.

[664] Nicole Carter, Stephen Mulligan & Clare Seelke, *U.S.-Mexican Water Sharing: Background and Recent Developments*, Congressional Research Service, 2017, p.16.

[665] Nicole Carter, Stephen Mulligan & Clare Seelke, *U.S.-Mexican Water Sharing: Background and Recent Developments*, Congressional Research Service, 2017, p.14.

[666] Nicole Carter, Stephen Mulligan & Clare Seelke, *U.S.-Mexican Water Sharing: Background and Recent Developments*, Congressional Research Service, 2017, p.9.

[667] M.I. Gunning, "The Projected Impact of the North American Free Trade Agreement on Transboundary Water Management Between Mexico and the U.S.A.," in J. Ganoulis, L. Duckstein, P. Literathy & I. Bogardi, eds. *Transboundary Water Resources Management: Institutional and Engineering Approaches*, 1994, pp.72-73.

until the 1990s, the wastewater from the Mexican side of the Rio Grande was deployed untreated into the river.[668]

One of the important problems over time between the US and Mexico with Colorado water has become salinization caused by agricultural activity in the Imperial Valley upstream. This issue emerged in the 1960s and the salinity level of the Colorado River water had adverse impacts on Mexican farmers. To facilitate the solution of the problem, the US government agreed to take some measures in accordance to the minute process.[669] Thereupon, in August 1973, the Minute 242 was signed between the two countries. Accordingly, the US would "adopt measures to assure that […] the approximately 1,360,000 acre-feet (1,677,545,000 cubic meters) delivered to Mexico upstream of Morelos Dam, have an annual average salinity of no more than 115 p.p.m. ± 30 p.p.m. […] over the annual average salinity of Colorado River waters which arrive at Imperial Dam […]"[670]

4.3.4. Agriculture and irrigation

The Colorado River basin has been one of the most famous river basins in the US in terms of water development. Especially in the Lower Colorado River basin, there are iconic and major dams, such as the Hoover Dam and its reservoir known as the Lake Mead, the Glen Canyon Dam with its reservoir the Lake Powell, the Davis Dam and its reservoir the Lake Mohave, the Parker Dam that formed the Havasu reservoir, the Headgate Rock Dam, the Palo Verde Diversion Dam, the Senator

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668 Roberto Suro, "Border Boom's Dirty Residue Imperils U.S.-Mexico Trade," *The New York Times*, 1991, available at: http://www.nytimes.com/1991/03/31/us/border-boom-s-dirty-residue-imperils-us-mexico-trade.html?pagewanted=all (accessed 3 August 2017).

669 Nicole Carter, Stephen Mulligan & Clare Seelke, *U.S.-Mexican Water Sharing: Background and Recent Developments*, Congressional Research Service, 2017, p.10.

670 International Boundary and Water Commission United States and Mexico, *Minute 242: Permanent and Definitive Solution to the International Problem of the Salinity of the Colorado River*, August 30, 1973, p.1.

Wash Dam, the Imperial Dam, the Laguna Dam, and the Morelos Dam in Mexico.[671] These dams provide water to vast arid and semi-arid lands and generate hydroelectricity for the demand centers in the American West.

The biggest among the abovementioned dams, the Hoover, the Davis, and the Parker, which operate under the responsibility of the USBR, have the capacity of about 9 million acre-feet (11.1 cubic kilometers) of water.[672] In total, the dams and reservoirs on the Colorado River basin have the capacity of 60 million acre-feet (about 74 cubic kilometers). Two largest reservoirs, the Mead and the Powell together have 83 percent of total water storage capacity in the basin.[673] As of 2016, the percentage of live storage in the Lake Powell and the Lake Mead are 48.5 and 38.6 percent, respectively.[674] The latest drought conditions has led to a decrease in the water levels in the Lake Powell and the Lake Mead (Figure 4.4).[675]

Located in the south near the Mexican border is a grand irrigation project, known as the Imperial Irrigation District, which is fed by a network of canals, including the All American Canal, and receives water from the Imperial Diversion Dam.[676]

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[671] US Department of the Interior, *The Colorado River: A Natural Menace Becomes a National Resource*, The Bureau of Reclamation, 1946.

[672] US Geological Survey, "Colorado River Story Map," *Texas Water Science Center*, 2017, available at: https://txpub.usgs.gov/DSS/StoryMaps/BlueDragon/ (accessed 21 August 2017).

[673] US Department of the Interior, "Drought in the Colorado River Basin," *Department of the Interior*, 2017, available at: https://www.doi.gov/water/owdi.cr.drought/en (accessed 21 August 2017).

[674] US Bureau of Reclamation, *Colorado River Accounting and Water Use Report: Arizona, California, and Nevada*, Lower Colorado Region, Boulder Canyon Operations Office, 2017, available at: https://www.usbr.gov/lc/region/g4000/4200Rpts/DecreeRpt/2016/2016.pdf (accessed 22 August 2017), p.5.

[675] US Bureau of Reclamation, *Colorado River Accounting and Water Use Report: Arizona, California, and Nevada*, Lower Colorado Region, Boulder Canyon Operations Office, 2017, available at: https://www.usbr.gov/lc/region/g4000/4200Rpts/DecreeRpt/2016/2016.pdf (accessed 22 August 2017)

[676] US Geological Survey, "Colorado River Story Map," *Texas Water Science Center*, 2017, available at: https://txpub.usgs.gov/DSS/StoryMaps/BlueDragon/ (accessed 21 August 2017).

In the Lower Colorado Basin, the Imperial Irrigation District is by far the largest user of water with about 2.7 million acre-feet (about 3.3 cubic kilometers) of annual average water use between 2010 and 2014.[677] The second largest user of water is the Central Arizona Project, with nearly 600 kilometers of irrigation and water delivery network.[678] It used about 1.6 million acre-feet (about 2 cubic kilometers) annually during the same time-period. The Central Arizona Project is followed by the Metropolitan Water District of Southern California with nearly 0.95 million acre-feet (about 1.2 cubic kilometers) of average annual water usage. Other users include the Palo Verde Irrigation District, Coachella Valley Water District, Wellton Mohawk Irrigation District, Southern Nevada Water authority, along with specific Indian tribes along the Colorado River and other small water users. The total average annual use of all remaining users, about 2 million acre-feet (less than 2.5 cubic kilometers) are less than the water used by the Imperial Irrigation District.[679] The Colorado River water is mostly dedicated to agricultural use within the borders of the US in one of the most arid regions of the world.

While crossing the international border, the Colorado water is held by the Morelos Diversion Dam. Mexico receives irrigation water to the Mexicali Valley from this

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[677] US Department of the Interior, "Drought in the Colorado River Basin," *Department of the Interior*, 2017, available at: https://www.doi.gov/water/owdi.cr.drought/en (accessed 21 August 2017).

[678] Central Arizona Project, "CAP Background," 2017, available at: www.cap-az.com (accessed 22 August 2017).

[679] US Department of the Interior, "Drought in the Colorado River Basin," *Department of the Interior*, 2017, available at: https://www.doi.gov/water/owdi.cr.drought/en (accessed 21 August 2017).

dam constructed on the international border, which is operated by the IBWC Mexico Section.[680] Similar to the Morelos, there are further major international reservoirs between the US and Mexico, such as the Falcon Dam and the Amistad Dam.[681] The Falcon Dam is the lowermost international multipurpose dam on the Rio Grande and is used for irrigation, flood control and hydropower generation purposes.[682] The Amistad is the largest storage on the Rio Grande international border.[683]

The Colorado River irrigates more than 5.5 million acres of land (about 2.3 million hectares).[684] One of the most important spots for agriculture in the West America is the San Luis Valley. Alfalfa, grass hay, barley, potatoes, and spring wheat are the dominant products of the valley agriculture. In Colorado, agricultural water withdrawal accounts for 80 percent of the total withdrawals.[685] Another region of agriculture is the Rio Grande Valley that is shared between the US and Mexico. The dominant economic activity in the Rio Grande Valley has been industry, trade, and

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[680] US Geological Survey, "Colorado River Story Map," *Texas Water Science Center*, 2017, available at: https://txpub.usgs.gov/DSS/StoryMaps/BlueDragon/ (accessed 21 August 2017).

[681] Nicole Carter, Stephen Mulligan & Clare Seelke, *U.S.-Mexican Water Sharing: Background and Recent Developments*, Congressional Research Service, 2017, p.8.

[682] International Boudnary & Water Commission, "Falcon Dam & Power Plant," *IBWC United States Section*, n.d., available at: https://www.ibwc.gov/Organization/Operations/Field_Offices/Falcon.html (accessed 11 September 2017).

[683] International Boundary & Water Commission, "Amistad Dam and Power Plant, Del Rio, Texas," *IBWC United States Section*, n.d., available at: https://www.ibwc.gov/Organization/Operations/Field_Offices/amistad.html (accessed 11 September 2017).

[684] US Department of the Interior, "Drought in the Colorado River Basin," *Department of the Interior*, 2017, available at: https://www.doi.gov/water/owdi.cr.drought/en (accessed 21 August 2017).

[685] DiNatale Water Consultants, *Rio Grande Basin Implementation Plan*, Rio Grande Basin Roundtable, 2015, p.8.

services since at least fifty years, after the industrialization policies of the Mexican government.

In addition, the Rio Grande Valley is one of the most important spots of economic activity in the region. The Valley includes the Port of Brownsville, a hub for waterway and land route connection. The prominent economic activity once was agriculture, but currently, trade and industry dominates economic activity. The total population in the valley is more than 3 million, one-third of which in the US, the remaining in Mexico. One of the most significant catalyzer of the industrial growth in the Rio Grande basin is Mexican factories, known as *maquiladoras* (Figure 4.6). These factories provide low-cost Mexican labor and attract high amounts of FDI, especially from the US.[686] The number of employees in the *maquiladoras* increased 2.5 to 6.5 times between 1980 and 1990. The increase in population and economic activity is one of the most important reasons of the increase in the pollutant release into the Rio Grande.[687] Also, the factories are exempt not only from tariffs and duties, but also from the costly environmental responsibilities.[688]

As stated above, water is the key for agricultural economy particularly in the US, but also in Mexico. Furthermore, the Mexican government's industrialization policies made industrial water demand increase, and exacerbated the question of water quality in the region. Another important user of water in the West is electricity generation, and the following section investigates the role played by electricity generation and interconnections in the economic structure in the region.

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686 The Economist, "One River, One Country," *The Economist*, 1997, available at: http://www.economist.com/node/156381 (accessed 3 August 2017).

687 Richard Jones, "Environmental Degradation in a Dependent Region: The Rio Grande Valley of Mexico and Texas," *Social Education*, vol. 63, no. 2, 1999.

688 Roberto Suro, "Border Boom's Dirty Residue Imperils U.S.-Mexico Trade," *The New York Times*, 1991, available at: http://www.nytimes.com/1991/03/31/us/border-boom-s-dirty-residue-imperils-us-mexico-trade.html?pagewanted=all (accessed 3 August 2017).

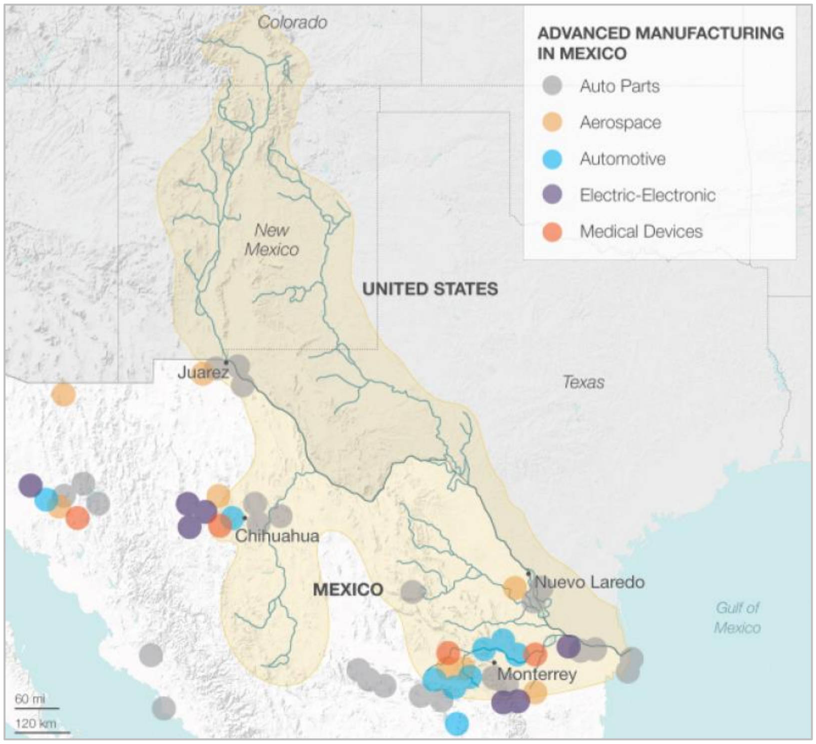

Figure 4.6. Mexican factories in the Rio Grande basin[689]

4.3.5. Water sharing in the north

In the north, there is more water to share. With the government of Canada, the issues with regards the transboundary waters are merely about environment and ecosystem protection. The large dams on the great rivers in North America have had a considerable impact on riverine ecosystems and fisheries, in a cumulative manner. The

[689] Stratfor, "Water: The Other U.S.-Mexico Border Issue," *Stratfor Worldview*, 2016 (accessed 7 September 2017).

eight dams on the Columbia River is found to reduce the amount of salmon fishes.[690]

The US and Canada share about 7,700 kilometers of borders. Through this long borderline, the countries share vast quantities of water. There are “nearly 300 lakes, rivers and streams” along the border.[691] In terms of the transboundary rivers, the two countries share 90 major streams through their boundaries. Among these, 50 rivers flow from Canada towards the US. Thus, the US has neither a clear upstream nor a definitive downstream position in this relationship.[692] In recent years, some authors observe, the US-Canada transboundary water management has been “re-scaled.” In other words, the local and regional organizations play a more decisive role than the national governments. This evolved transboundary water management between the US and Canada involves a process, in which the rights of local and indigenous people are considered.[693]

On some occasions, the environmentalist groups formed transboundary alliances against the building of dams and HPPs in order to protect the natural setting of Washington and British Columbia. An important case was the plans for building of the Ross Dam on the Skagit River. The HPP here generates electricity for Seattle, a city with about 700 thousand population as of 2016. The Seattle Light Company, the operator of the dam, wanted to raise the dam in order to increase hydropower

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[690] Stuart Orr, Jamie Pittock, Ashok Chapagain & David Dumaresq, "Dams on the Mekong River: Lost Fish Protein and the Implications for Land and Water Resources," *Global Environmental Change*, vol. 22, no. 4, 2012, p.926.

[691] David Lemarquand, "Preconditions to Cooperation in Canada–United States Boundary Waters," *Natural Resources Journal*, vol. 26, no. 2, 1986, p.221.

[692] David Lemarquand, "Preconditions to Cooperation in Canada–United States Boundary Waters," *Natural Resources Journal*, vol. 26, no. 2, 1986, p.223.

[693] See: Emma Norman & Karen Bakker, "Transgressing Scales: Water Governance Across the Canada–U.S. Borderland," *Annals of The Association of American Geographers*, vol. 99, no. 1, 2009; Emma Norman & Karen Bakker, "Do good fences make good neighbours? Canada–United States transboundary water governance, the Boundary Waters Treaty, and twenty-first-century challenges," *Water International*, vol. 40, no. 1, 2015.

generation. However, as it would inundate valuable wilderness areas, the project created controversy. This controversy was resolved through an agreement between the governments of the US and Canada for electricity trade. Accordingly, Canada would supply the additional demand for electricity in the US.[694] The agreement is in line with the "absolute territorial integrity" doctrine, or the "watershed approach" to the management of the international water resources.

As the US-Canada borderline is more water-abundant, hydroelectricity generation is on higher level here. The following section discusses the hydroelectricity generation efforts and interconnections, which are intensified in the north.

4.4. Electricity and interconnections

The US has been one of the pioneers in electricity generation, hydroelectricity, and electricity trade. Despite the presence of the bilateral trade regulations like the NAFTA, the interconnectedness in the North America remained on lower levels, especially between the US and Mexico. This section focuses on hydropower generation and trade of the US with its neighbors, Canada and Mexico.

The history of electricity in the US dates back to late nineteenth century. In September 1882, Thomas Edison built a steam electric generator at Appleton, Wisconsin, and the first HPP in America began functioning. This was established with two dynamos patented to Edison, which had a capacity of lighting 550 lamps.[695] This decade of the late nineteenth century witnessed great developments of hydroelectricity in America. By the 1880s, at least forty HPPs were in operation, of which nearly half was in West America. In the far west, near the Colorado and the Rio

[694] Jeff Dornbos, "All (Water) Politics is Local: A Proposal for Resolving Transboundary Water Disputes," *Fordham Environmental Law Review*, vol. 22, 2011.

[695] Robert Shortridge, "Some Early History of Hydroelectric Power," June 1988, p.31

Grande, HPPs in operation were in Aspen, Salt Lake City, and Ogden City.[696] Utah and Ogden were the pioneers of electricity in the west of America. Salt Lake City was the fifth city in the world that had a centralized system of lighting in the world, after London, New York, San Francisco and Cleveland.[697] The electricity came to Utah in 1881 with the Salt Lake City Light, Heat, and Power Company.[698] The first HPPs were rather small and local facilities lacked proper equipment and financing. They were established on canyon streams, the velocities of which were highly volatile.[699] In due course, HPPs were constructed nearly in each and every canyon in Utah.[700] Also, the world's first 40 kV transmission line, the longest in the world at that time, was built in Utah in the late 1890s.[701] The Mormon Church was active in HPP building and hydroelectricity sector. The Pioneer Electric Power Company was an example of this. In 1893, George Q. Cannon, a preeminent Mormon became the president of the company, which built a dam for hydroelectricity and irrigation

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[696] Robert Shortridge, "Some Early History of Hydroelectric Power," June 1988, p.32. See also: City of Aspen, "Aspen's Hydroelectric History," *City of Aspen Colorado*, 2008, available at: http://www.aspenpitkin.com/living-in-the-valley/green-Initiatives/renewable-energy/hydroelectric/ (accessed 21 November 2016); Aspen Historical Society, "Hydropower Pioneers of Aspen," 1958, available at: https://www.youtube.com/watch?v=fAgxUVmuVCE (accessed 19 November 2016).

[697] Obed Haycock, "Electric Power Comes to Utah," *Utah Historical Quarterly*, vol. 45, no. 2, 1977, p.174.

[698] John McCormick, "Electrical Development in Utah," 2016, available at: http://www.uen.org/utah_history_encyclopedia/e/ELECTRICAL_DEVELOPMENT.html (accessed 22 November 2016).

[699] John McCormick, "The Beginning of Modern Electric Power Service in Utah, 1912-22," *Utah Historical Quarterly*, vol. 56, no. 1, 1988, pp.6-7.

[700] Obed Haycock, "Electric Power Comes to Utah," *Utah Historical Quarterly*, vol. 45, no. 2, 1977, p.177

[701] Obed Haycock, "Electric Power Comes to Utah," *Utah Historical Quarterly*, vol. 45, no. 2, 1977, p.179. The first attempts of electric transmission were with direct current. See: Massimo Guarnieri, "The Beginning of Electric Energy Transmission: Part One," *IEEE Industrial Electronics Magazine*, vol. March, 2013, p.51.

on Ogden River.[702] In the same year, the first alternating current HPP, the Redlands, was installed in California, near Mill Creek.[703]

With these developments in technology, small and local HPPs were able to grow more efficient. Also, the HPPs began to be interlinked with high-voltage transmission lines,[704] thus the first examples of grids began appearing. By 1922, the 40 HPPs of the Utah Power and Light Company were interconnected with transmission lines through a main distribution center located in Salt Lake City.[705] Transnational electricity transmission lines began appearing earlier. The first recorded electricity transmission line that crossed a national border was constructed between the US and Canada in 1901.[706] By the year 1920, more than 300 HPPs were active all over the US. These were mostly private, small or medium-sized establishments. The first large HPPs also appeared in the 1920s, which were the Wilson Dam in Alabama and the Conowingo Dam in Maryland.[707]

In 1920, with the Federal Power Act, the Federal Power Commission was established. This commission had a duty of granting licenses of hydropower on public

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[702] Obed Haycock, "Electric Power Comes to Utah," *Utah Historical Quarterly*, vol. 45, no. 2, 1977, p.183.

[703] US Department of Energy, "History of Hydropower," *Energy.gov*, 2016a, available at: https://www.energy.gov/eere/water/history-hydropower (accessed 16 December 2016).

[704] Matthew Brown & Richard Sedano, *Electricity Transmission: A Primer* (Washington, DC: National Council on Electric Policy, 2004), pp.2-3.

[705] John McCormick, "The Beginning of Modern Electric Power Service in Utah, 1912-22," *Utah Historical Quarterly*, vol. 56, no. 1, 1988, p.12.

[706] J. Charpentier & K Schenk, International Power Interconnections: Moving from electricity exchange to competitive trade, The World Bank, 1995.

[707] Rocío Uría-Martínez, Patrick O’Connor & Megan Johnson, *2014 Hydropower Market Report, May 2016 Update Data*, US Department of Energy, 2016 (accessed 28http://energy.gov/sites/prod/files/2016/05/f31/Hydropower-Market-Report-May-2016-Update-Data_20160506.xlsx November 2016), p.8.

estates.[708] In 1933, the construction of the Grand Coulee Dam was initiated, which was initially planned as a small dam with the purpose of irrigation only. With the encouragement of Franklin Roosevelt, it was transformed into a high dam with its 550 feet (nearly 170 meters) height upon its completion in 1942. The works to expand the dam continued between 1967 and 1974 and the total installed capacity was increased to 6,800 megawatts, making it the largest electricity generator in the country.[709] The works here included water lifting pump stations for irrigation and its electricity supports the military and nuclear industry in the Northwest.[710]

By the beginning of the twenty-first century, more than 75,000 dams were constructed on the rivers of the US. This made 98 percent of all water flow in the country fragmented.[711] Until the 1960s, the installed capacity increased steadily with the completion of larger dams and in the 1970s, due to environmental concerns, licensing of large dams came almost to a halt.[712] The length of transmission lines increased during the course of time as well. As of 2002, more than 240,000 kilometers

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[708] Rocío Uría-Martínez, Patrick O'Connor & Megan Johnson, *2014 Hydropower Market Report, May 2016 Update Data*, US Department of Energy, 2016 (accessed 28http://energy.gov/sites/prod/files/2016/05/f31/Hydropower-Market-Report-May-2016-Update-Data_20160506.xlsx November 2016), p.3.

[709] John Baptist & Roy Nitta, "Electrical Features of the Grand Coulee Third Power Plant," *IEEE Spectrum*, 1969.

[710] Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Oxford University Press, 1985), p.271.

[711] Molly Pohl, "Channel Bed Mobility Downstream from the Elwha Dams, Washington," *The Professional Geographer*, vol. 56, no. 3, 2004, p.422.

[712] Rocío Uría-Martínez, Patrick O'Connor & Megan Johnson, *2014 Hydropower Market Report, May 2016 Update Data*, US Department of Energy, 2016 (accessed 28http://energy.gov/sites/prod/files/2016/05/f31/Hydropower-Market-Report-May-2016-Update-Data_20160506.xlsx November 2016), p.8.

of alternating current and more than 5,000 kilometers direct current transmission lines were in operation in the whole country.[713]

4.4.1. Economy and electricity production

Although not the main fuel for electricity generation, water is very important for power generation in the US and Canada, which rank among the top hydropower producers globally. As of 2016, these countries possessed 102.5 and 98 gigawatts total installed hydropower generating capacities (including pumped storage), respectively. This corresponds to nearly 16 percent of the whole installed hydropower capacity in the world. It is important to note that even solely the total pumped storage capacity in the US is significantly high. As a comparison, the 2015 pumped storage capacity in the US (22.2 gigawatts) was higher than the *total* hydropower capacity in Italy or Spain, slightly less than the total capacity of the HPPs in Turkey or in France. In general, while the US possesses one of the largest hydropower generation capacities in the world, this represents only about 6 percent of the total electricity production capacity in the country (Figure 4.7).[714] Nearly 70 percent is produced using hydrocarbons.

Public sector dominates the ownership of the HPPs in the US. Privately-owned HPPs correspond only to 27 percent of all installed plant capacity. Of the non-private HPPs, 49 percent capacity belong to the federal government.[715] In general, one may argue that the high involvement of the federal government is a consequence of

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[713] Matthew Brown & Richard Sedano, *Electricity Transmission: A Primer* (Washington, DC: National Council on Electric Policy, 2004), pp.5-6.

[714] International Hydropower Association, "World hydropower statistics," *IHA*, 2016, available at: https://www.hydropower.org/world-hydropower-statistics (accessed 14 October 2017); International Hydropower Association, "USA Country Profile," *IHA Maps and Statistics*, 2016, available at: https://www.hydropower.org/country-profiles/usa (accessed 2 December 2016).

[715] Rocío Uría-Martínez, Patrick O'Connor & Megan Johnson, *2014 Hydropower Market Report, May 2016 Update Data*, US Department of Energy, 2016 (accessed 28http://energy.gov/sites/prod/files/2016/05/f31/Hydropower-Market-Report-May-2016-Update-Data_20160506.xlsx November 2016), pp.12-13.

the size of large HPP schemes, especially those in the West. The private sector may not always be able to finalize grand projects. Also, during the course of the history, the size of the water bureaucracies grew so large that they needed further hydraulic projects to continue their life and to get political approval.[716]

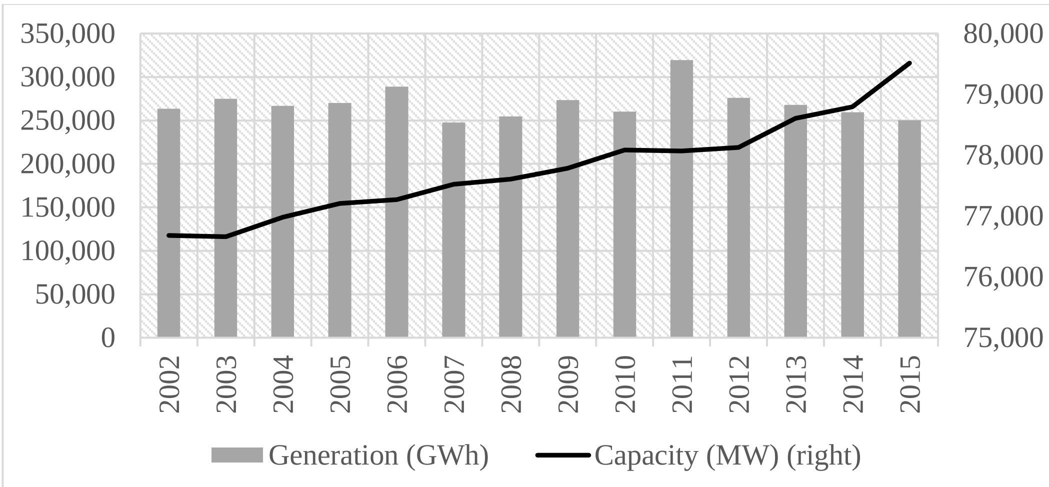

Figure 4.7. Total US installed hydropower capacity and hydropower generation[717]

The total electricity demand is so great in the US that it is almost impossible to meet this demand by exploiting the hydropower resources of the country. By 2014, there were nearly 2,200 hydropower plants with about 5,600 turbine-generators. Not all

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[716] See: Roy Carriker & L. Wallace, "Government Involvement In Water Use And Development: More Or Less, And At What Level?," *Increasing Understanding of Public Problems and Policies*, 1982.

[717] The figure excludes pumped storage hydropower capacity. Rocío Uría-Martínez, Patrick O'Connor & Megan Johnson, *2014 Hydropower Market Report*, *May 2016 Update Data*, US Department of Energy, 2016 (accessed 28http://energy.gov/sites/prod/files/2016/05/f31/Hydropower-Market-Report-May-2016-Update-Data_20160506.xlsx November 2016).

the HPPs have a dam and reservoir, some of them are run-of-river type generators.[718] At the same time, of more than 80,000 dams in the whole country, only 3 percent have a HPP installed.[719]

Hydroelectricity is not equally developed across the US and the generation capacity was distributed quite unequally across the country. Nearly 50 percent of all the installed capacity are in the states of Washington, California and Oregon.[720] Among the greatest ten HPPs, Washington has four: the Grand Coulee (ranking first), the Chief Joseph (ranking second), the Rocky Reach and the Wanapum dams.[721] Among all the US states, Delaware and Mississippi do not possess any HPPs. As of end-2013, Washington produced three-quarters of its total electricity from HPPs, while Idaho and Oregon produced nearly two-thirds of the total.[722] The Columbia River basin is the most important hydropower generating region in the country. The electricity produced in this basin corresponds to 40-44 percent of all hydropower

[718] International Hydropower Association, "USA Country Profile," *IHA Maps and Statistics*, 2016, available at: https://www.hydropower.org/country-profiles/usa (accessed 2 December 2016); Rocío Uría-Martínez, Patrick O'Connor & Megan Johnson, *2014 Hydropower Market Report, May 2016 Update Data*, US Department of Energy, 2016 (accessed 28http://energy.gov/sites/prod/files/2016/05/f31/Hydropower-Market-Report-May-2016-Update-Data_20160506.xlsx November 2016), p.5.

[719] International Hydropower Association, "USA Country Profile," *IHA Maps and Statistics*, 2016, available at: https://www.hydropower.org/country-profiles/usa (accessed 2 December 2016).

[720] Rocío Uría-Martínez, Patrick O'Connor & Megan Johnson, *2014 Hydropower Market Report, May 2016 Update Data*, US Department of Energy, 2016 (accessed 28http://energy.gov/sites/prod/files/2016/05/f31/Hydropower-Market-Report-May-2016-Update-Data_20160506.xlsx November 2016), p.6.

[721] Oak Ridge National Laboratory, "Archived Existing Hydropower Assets Data and Maps," *National Hydropower Asset Assessment Program*, 2015, available at: https://nhaap.ornl.gov/eha-archived (accessed 28 November 2016).

[722] Rocío Uría-Martínez, Patrick O'Connor & Megan Johnson, *2014 Hydropower Market Report, May 2016 Update Data*, US Department of Energy, 2016 (accessed 28http://energy.gov/sites/prod/files/2016/05/f31/Hydropower-Market-Report-May-2016-Update-Data_20160506.xlsx November 2016), pp.5-6.

generated in the country.[723] About 70 percent of all the HPPs in the Columbia River basin is owned by the US federal government, and 19 percent by the municipalities.[724] Another important basin is the Colorado River basin, where water is more scarce. The three major HPPs on the Colorado River, the Hoover, the Davis, and the Parker dams, produce more than 6.5 billion kWh of electricity annually.[725]

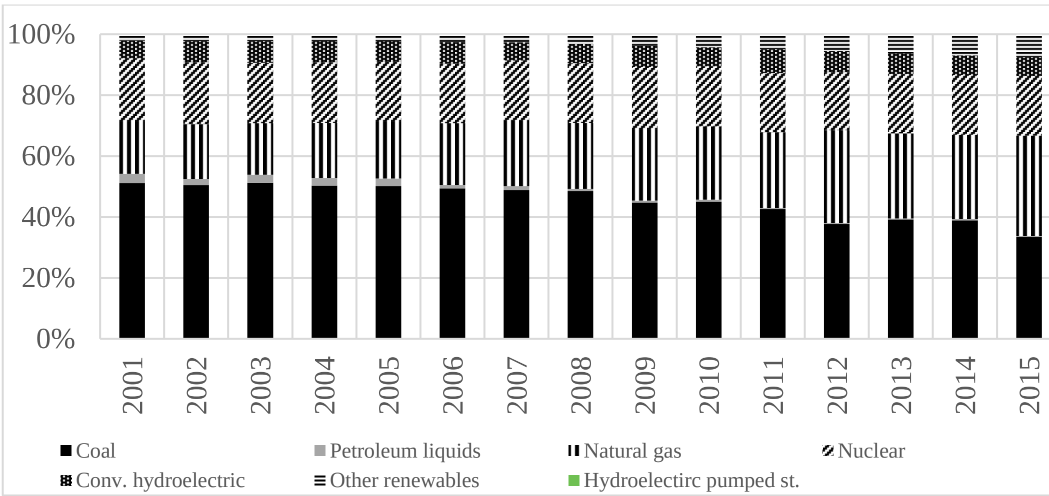

Figure 4.8. US net electricity generation[726]

[723] International Hydropower Association, "USA Country Profile," *IHA Maps and Statistics*, 2016, available at: https://www.hydropower.org/country-profiles/usa (accessed 2 December 2016); US Energy Information Administration, "The Columbia River Basin provides more than 40% of total U.S. hydroelectric generation," *EIA*, 2017, available at: https://www.eia.gov/todayinenergy/detail.php?id=16891 (accessed 14 February 2018).

[724] US Energy Information Administration, "The Columbia River Basin provides more than 40% of total U.S. hydroelectric generation," *EIA*, 2017, available at: https://www.eia.gov/todayinenergy/detail.php?id=16891 (accessed 14 February 2018).

[725] US Geological Survey, "Colorado River Story Map," *Texas Water Science Center*, 2017, available at: https://txpub.usgs.gov/DSS/StoryMaps/BlueDragon/ (accessed 21 August 2017).

[726] US Energy Information Administration, "Electricity Data Browser," *EIA*, 2015, available at: http://www.eia.gov/ (accessed 29 November 2016).

The Figure 4.9 is indicative for the importance of the West in terms of hydroelectricity and hydraulic works, as well as the contribution of the large state-led hydraulic works to the increase of prominence of the hydraulic bureaucracy in the US. As stated above, the northern part of the West has a foothold in hydroelectricity generation. The interconnections are also more developed and high-capacity in the north, and the volume of electricity trade is higher.

In the north, Canada has a considerable hydropower potential. It is the third largest producer of hydroelectricity in the world with an installed capacity of 77.6 gigawatts and 375 TWh of generation as of 2014. There is also an additional 160 gigawatts of development potential.[727] Yet, not all the potential may be feasible or appropriate for development. One of the reasons for this is the opposition of local people and the environmentalist groups.[728]

Unlike the US, Canadian electricity production depends on hydroelectricity. The top five hydroelectricity producing regions of the country are Quebec, British Columbia, Ontario, Newfoundland and Labrador, and Manitoba.[729] Canada is the third largest exporter of electricity in the world after Germany and France, with its 68 billion kWh of total electricity exports to the US.[730]

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[727] International Hydropower Association, "Canada Country Report," *IHA Maps and Statistics*, 2015, available at: https://www.hydropower.org/country-profiles/canada (accessed 2 December 2016).

[728] In 1994, a HPP Project, the Great Whale, was abandoned due to criticism of environmentalists and Aboriginal people. See: Adrian Van den Hoven & Karl Froschauer, "Limiting Regional Electricity Sector Integration and Market Reform: The Cases of France in the EU and Canada in the NAFTA Region," *Comparative Political Studies*, vol. 37, no. 9, 2004, p.1086.

[729] Pierre-Olivier Pineau, *Integrating Electricity Sectors in Canada: Good for the Environment and for the Economy*, The Federal Idea, 2012, p.8.

[730] International Energy Agency, "Total Electricity Exports - 2015," *EIA Beta*, 2015, available at: http://www.eia.gov/beta/international/?fips=MX (accessed 10 January 2017).

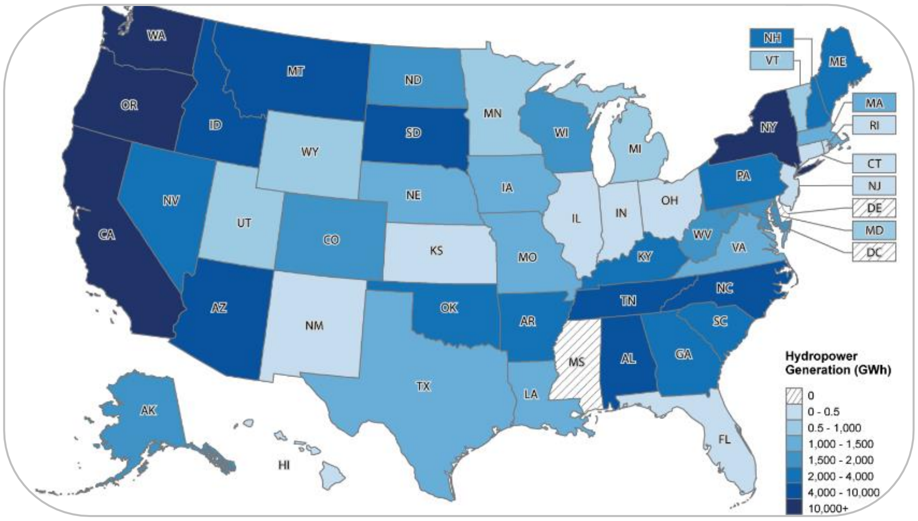

Figure 4.9. Net hydropower generation in the US (GWh) in 2015[731]

4.4.2. Interconnections

The electricity grid of North America comprises of five regions of different sizes. Three minor interconnections of Texas, Quebec, and Alaska as well as two major interconnections, the Eastern and the Western, are in operation in the continent. The Eastern Interconnection includes the central part of North America and Canada in the north and Louisiana and Florida in the south and stretches towards the Atlantic Ocean in the East. The Western Interconnection includes the northeastern part of the US and Western Canada and stretches towards Baja California in Mexico.[732] The link between the Eastern and Western Interconnection is established with direct

[731] Oak Ridge National Laboratory, "Archived Existing Hydropower Assets Data and Maps," *National Hydropower Asset Assessment Program*, 2015, available at: https://nhaap.ornl.gov/eha-archived (accessed 28 November 2016).

[732] US Department of Energy, "Learn More about Interconnections," *Office of Electricity Delivery & Energy Reliability*, 2016, available at: http://energy.gov/oe/services/electricity-policy-coordination-and-implementation/transmission-planning/recovery-act-0 (accessed 25 November 2016).

current transmission lines. This is intended to control the flows between the two systems.[733]

The Western Electricity Coordinating Council (WECC) is the single responsible body for the reliability of the electricity system in the Western Interconnection, while there are six separate regional bodies responsible for the East.[734] The Western Interconnection is comprised of 121,200 circuit-miles (nearly 200,000 kilometers) of lines, while the Eastern has 273,140 circuit-miles-long (nearly 440,000 kilometers) lines. One major difference between the West and the East is that the former carries the electricity very long distances between electricity production centers to the consumption centers that are mostly on the West Coast.[735] Peak energy demand in the Western Interconnection was 150,700 megawatts in summer 2015 and 126,200 megawatts in winter 2014-2015. Total energy consumption during this time period was 883,600 GWh.[736]

With the free trade agreement in 1989 signed between the US and Canada, import and export restrictions on energy were lifted.[737] Shortly afterwards, Mexico joined this partnership and following some debates about job markets and economic development, Canada, the US and Mexico signed the North American Free Trade

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[733] Matthew Brown & Richard Sedano, *Electricity Transmission: A Primer* (Washington, DC: National Council on Electric Policy, 2004), p.37.

[734] WECC, *2016 State of the Interconnection*, Western Electricity Coordinating Council, 2106, p.ii.

[735] WECC, *2016 State of the Interconnection*, Western Electricity Coordinating Council, 2106, p.vi.

[736] WECC, *2016 State of the Interconnection*, Western Electricity Coordinating Council, 2106, p.10.

[737] M. Villareal & Ian Ferguson, *The North American Free Trade Agreement (NAFTA)*, The US Congress, 2015, p.3

Agreement (NAFTA) that entered force as of 1994. Since then, regional trade developed, either with the impact of the NAFTA or not,[738] from its initial level of 290 billion US dollars to more than 1.1 trillion US dollars in 2016.[739] The lifting of restrictions on energy trade with the 1989 agreement was repeated with the NAFTA as well, yet Mexico was excluded from this provision.[740] The NAFTA contributed to the trade of hydrocarbons quite significantly,[741] but the electricity trade between these countries remained on lower levels.

Burgos argues that in the Western Hemisphere, North America has a special place with respect to electricity integration. Yet the major part of this integration is between the US and Canada.[742] In their comparative analysis conducted in 2004, Pineau et al. expected that the integration in North America would be high, yet their indicators showed that the trilateral integration in the region was low and the regional integration is rather based on bilateral ties, namely between the US and Canada, and between the US and Mexico, in a separate manner.

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[738] M. Villareal & Ian Ferguson, *The North American Free Trade Agreement (NAFTA)*, The US Congress, 2015.

[739] James McBride & Mohammed Sergie, "NAFTA's Economic Impact," *CFR Backgrounders*, 2016, available at: http://www.cfr.org/trade/naftas-economic-impact/p15790 (accessed 26 November 2016).

[740] M. Villareal & Ian Ferguson, *The North American Free Trade Agreement (NAFTA)*, The US Congress, 2015, p.3.

[741] M. Villareal & Ian Ferguson, *The North American Free Trade Agreement (NAFTA)*, The US Congress, 2015, p.11.

[742] Francisco Burgos, Regional electricity cooperation and integration in the Americas: Potential environmental, social and economic benefits, Organization of the American States, 2007, p.5.

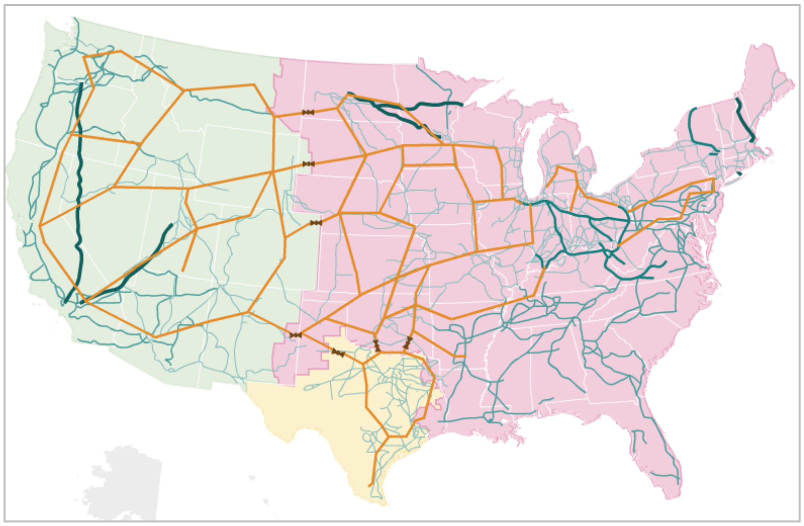

Figure 4.10. The Eastern, Western and Texas Interconnections[743]

One may observe that the integration between the US and Canada is much higher in comparison to the integration between the US and Mexico (Figure 4.11).[744] As the regional electricity integration in North America is lower than intended[745] despite the presence of long-established regional bodies encouraging regional trade, such as the NAFTA, there are some reasons for this difference between the trade volumes with the northern and the southern neighbor of the US. First, the interconnector infrastructure is more developed between the US and Canada, and the number of border crossings is higher on the US-Canada borderline. Second, the

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[743] NPR, "Visualizing The U.S. Electric Grid," *NPR*, 2009, available at: http://www.npr.org/2009/04/24/110997398/visualizing-the-u-s-electric-grid (accessed 25 November 2016).

[744] Pierre-Olivier Pineau, Anil Hira & Karl Froschauer, "Measuring International Electricity Integration: A Comparative Study of the Power Systems under the Nordic Council, MERCOSUR, and NAFTA," *Energy Policy*, vol. 32, 2004, pp.1468-73.

[745] Pierre-Olivier Pineau, Anil Hira & Karl Froschauer, "Measuring International Electricity Integration: A Comparative Study of the Power Systems under the Nordic Council, MERCOSUR, and NAFTA," *Energy Policy*, vol. 32, 2004.

generating capacity in Mexico is half of the generating capacity in Canada. Third, there have been historical and political disagreements between the US and Mexico.

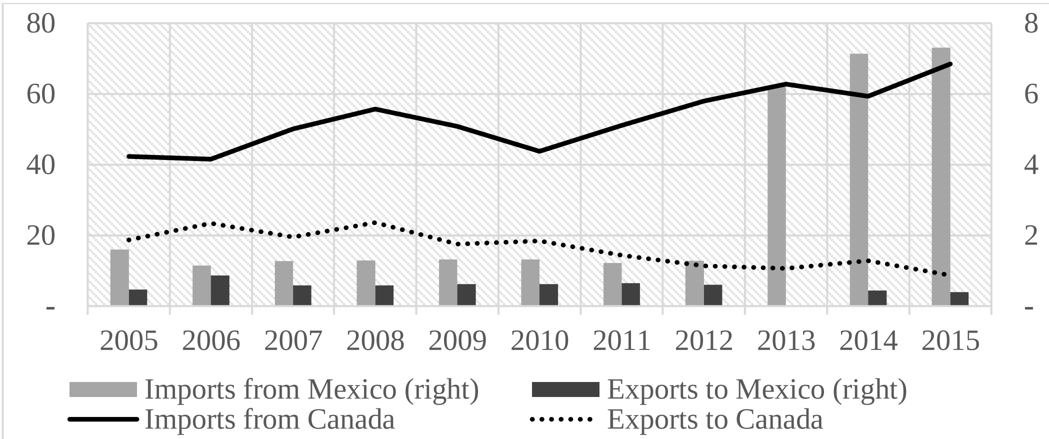

Figure 4.11. US electricity trade (TWh)[746]

According to the US Energy Information Administration, there are ten electricity border crossings between the US and Mexico with carriage capacities between 69 kV and 230 kV (Figure 4.12). The electricity trade between the US and Mexico takes place in California, New Mexico and Texas. In California, the US imports electricity to meet the demand in San Diego.[747] Canada and the US are more integrated. Between the two countries, there are 27 interconnections with lines between 12 kV and 765 kV.[748] A major difference between Canada and Mexico as partners

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[746] US Energy Information Administration, "Electric Power Industry - U.S. Electricity Imports from and Electricity Exports to Canada and Mexico," *EIA Statistics*, 2015b, available at: https://www.eia.gov/electricity/annual/html/epa_02_13.html (accessed 3 December 2016)

[747] US Energy Information Administration, "Mexico Week: U.S.-Mexico electricity trade is small, with tight regional focus," *EIA*, 2013, available at: http://www.eia.gov/todayinenergy/detail.php?id=11311 (accessed 10 January 2017).

[748] US Energy Information Administration, "US Energy Mapping System," *EIA*, 2016, available at: http://www.eia.gov/state/maps.cfm?src=home-f3 (accessed 29 November 2016).

of electricity trade with the US is that in Mexico, almost all power plants belong to the state-led monopoly, the Comisión Federal de Electricidad,[749] while in Canada, the weight of the private sector is higher.

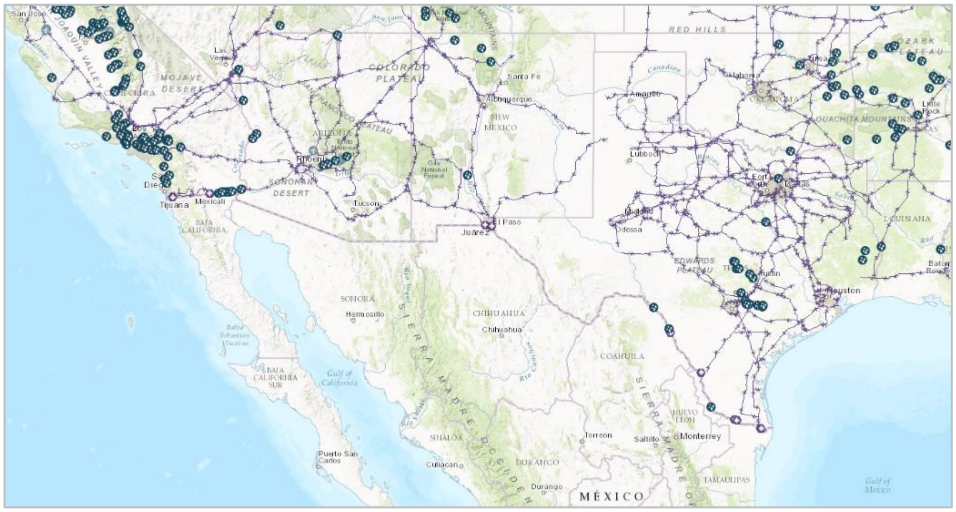

Figure 4.12. HPPs and electricity border crossings in the southern US[750]

The energy links between the US and Canada are more developed than the links between the US and Mexico (Figure 4.11). As of 2015, the US imported 68 TWh of electricity from Canada and 7 TWh from Mexico. It is important to note that in 2013, the US Energy Information Administration has revised the methodology of estimating US imports from Mexico. This may be a reasonable explanation for the

[749] US Energy Information Administration, "Mexico Week: U.S.-Mexico electricity trade is small, with tight regional focus," *EIA*, 2013, available at: http://www.eia.gov/todayinenergy/detail.php?id=11311 (accessed 10 January 2017).

[750] US Energy Information Administration, "US Energy Mapping System," *EIA*, 2016, available at: http://www.eia.gov/state/maps.cfm?src=home-f3 (accessed 29 November 2016).

steep increase in import figures since 2013.[751] Despite this, electricity trade with Mexico remains marginal relative to the trade with Canada.

In Canada, there has been a trend of increase in the installed hydropower capacity since the 1960s and the governments of Canada encouraged export of electricity to the US. The major private electricity producers in Canada have had a considerable impact on the governments with respect to North American electricity markets integration.[752] With the contribution of the new hydroelectricity development projects in the 1970s and the 1980s, a great surplus of electricity occurred. Some examples of major development projects were: The Churchill Falls, the James Bay, the Nelson River, the Limestone, the Columbia and the Peace Rivers development projects. The surplus electricity was so high that some companies, i.e. Hydro-Quebec, was able to negotiate with the New York State on electricity exports. Usually, it was foreseen by the builders of the HPPs that the demand for the newly installed HPPs would not be as high as the generated electricity. This means that some HPPs were built solely for export purposes, especially in the 1970s. As a result, net electricity exports of Canada to the US increased between the 1970s and 1990s.[753] In the mid-2000s, however, an important issue emerged: electricity consumption in Canada was growing and it is growing faster than the generating capacity.[754]

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[751] US Energy Information Administration, "Electric Power Industry - U.S. Electricity Imports from and Electricity Exports to Canada and Mexico," *EIA Statistics*, 2015b, available at: https://www.eia.gov/electricity/annual/html/epa_02_13.html (accessed 3 December 2016)

[752] Adrian Van den Hoven & Karl Froschauer, "Limiting Regional Electricity Sector Integration and Market Reform: The Cases of France in the EU and Canada in the NAFTA Region," *Comparative Political Studies*, vol. 37, no. 9, 2004, pp.1083-86.

[753] Adrian Van den Hoven & Karl Froschauer, "Limiting Regional Electricity Sector Integration and Market Reform: The Cases of France in the EU and Canada in the NAFTA Region," *Comparative Political Studies*, vol. 37, no. 9, 2004, pp.1086-91.

[754] Richard Pierce, Michael Trebilcock & Evan Thomas, "Beyond Gridlock: The Case for Greater Integration of Regional Electricity Markets," *C.D. Howe Institute Commentary*, vol. 228, 2006.

Table 4-4. Canadian electricity exports to the US regions (TWh)[755]

	2011	2012	2013	2014	2015
Exports to West	9.70	10.90	7.00	7.40	12.70
Exports to Midwest	14.20	12.60	16.10	15.00	18.60
Exports to PJM	1.10	2.40	1.80	1.00	1.00
Exports to NYISO	12.10	16.20	18.70	16.90	17.90
Exports to ISO-NE	14.00	15.50	19.00	18.10	18.20
Exports (total)	**51.10**	**57.60**	**62.60**	**58.40**	**68.40**

According to the National Energy Board, as of 2015, electricity exports of Canada reached to a peak value of more than 68 TWh in gross and nearly 60 TWh in net terms, providing 3.1 billion Canada dollars (2.3 billion US dollars) of gross revenue to the country. The relatively higher prices of electricity in the US contributed to the increase of exports from Canada. This high volume of power trade includes the major hydropower producing regions in the US, i.e. the western America. The Canadian electricity exports to the western regions alone increased by 70 percent, year-on-year, as of 2015 (Table 4-4).[756] Studies show that differences between electricity market prices are desicive here, as observed in the example of electricity

[755] National Energy Board, "2015 Electricity Exports and Imports Summary," *National Energy Board*, 2016, available at: https://www.neb-one.gc.ca/nrg/sttstc/lctrct/stt/lctrctysmmr/2015/smmry2015-eng.html (accessed 3 December 2016).

[756] National Energy Board, "2015 Electricity Exports and Imports Summary," *National Energy Board*, 2016, available at: https://www.neb-one.gc.ca/nrg/sttstc/lctrct/stt/lctrctysmmr/2015/smmry2015-eng.html (accessed 3 December 2016).

trade between Ontario and neighboring US regions, New York, Michigan and Minnesota.[757] The highly integrated structure of electricity market has an impact on price convergence between regions.[758]

In North America, there are significant price differences even between neighboring regions. The main reasons for this is the difference in jurisdictions and difference in energy generation costs. In Idaho, for instance, because of regulated energy prices and low cost of hydroelectricity, electricity prices are low. In Canada, states such as Québec, Manitoba and British Columbia have lower prices because of regulation.[759] This aspect is usually criticized by some authors and official agencies[760] since price differences are in disfavor of consumers, especially in the deregulated price regions. The price of residential electricity in New York or Boston are approximately four times the price in Montréal (Figure 4.13). However, Pineau and Lefebvre argue that despite declining transmission capacity as indicated by official reports,[761] it is not easy to say that the lack of transmission capacity is "limiting profitable trade."[762]

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[757] Talat Genc, Ege Yazgan & Pierre-Olivier Pineau, "Electricity Trade Patterns in a Network," *Progress in Clean Energy*, vol. 2, 2014, p.691.

[758] Talat Genc, Ege Yazgan & Pierre-Olivier Pineau, "Electricity Trade Patterns in a Network," *Progress in Clean Energy*, vol. 2, 2014, p.688.

[759] Etienne Billette de Villemeur & Pierre-Olivier Pineau, "Regulation and Electricity Market Integration: When Trade Introduces Inefficiencies," *Energy Economics*, vol. 34, no. 2, 2012, p.531.

[760] Pierre-Olivier Pineau & Vincent Lefebvre, "The Value of Unused Interregional Transmission: Estimating the Opportunity Cost for Quebec (Canada)," *International Journal of Energy Sector Management*, vol. 3, no. 4, 2009, p.407; Eric Hirst, *US Transmission Capacity: Present Status and Future Prospects*, Edison Electric Institute, 2004.

[761] Eric Hirst, *US Transmission Capacity: Present Status and Future Prospects*, Edison Electric Institute, 2004, p.v.

[762] Pierre-Olivier Pineau & Vincent Lefebvre, "The Value of Unused Interregional Transmission: Estimating the Opportunity Cost for Quebec (Canada)," *International Journal of Energy Sector Management*, vol. 3, no. 4, 2009, p.420.

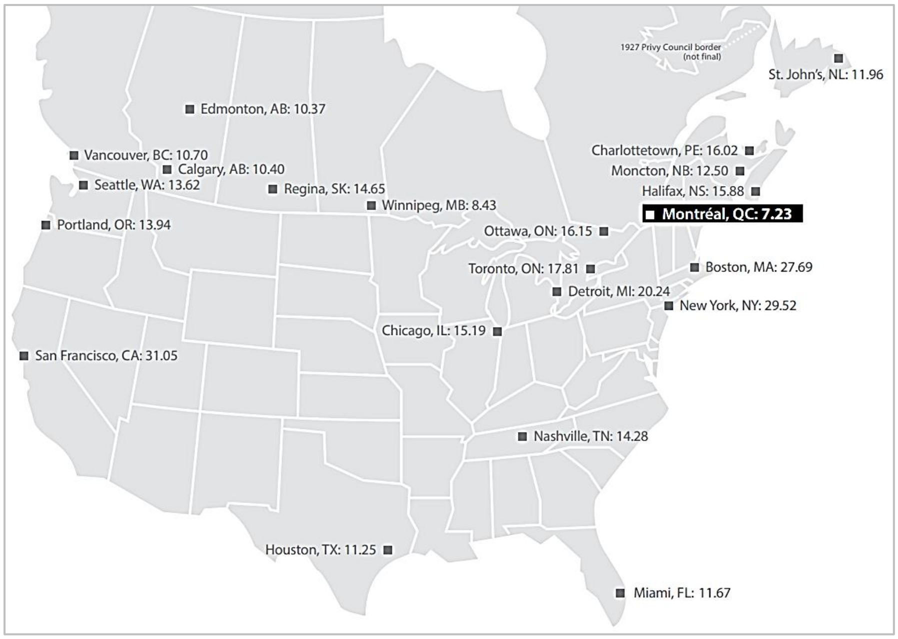

Figure 4.13. Electricity prices for residential customers in North America[763]

The authorities in the US plan to further develop the interconnection capacity in North America. For this purpose, a national program named "Grid 2030" was drafted in 2003 by the US Department of Energy.[764] The authorities foresee to connect the hydropower generating capacity in the Columbia River and the Great lakes basins to the rest of the transnational electricity grid.[765]

[763] Prices are in Canadian currency. The numbers indicate cents per kWh electricity in 2016 average. See: Hydro Québec, *Comparison of Electricity Prices in Major North American States*, Hydro Québec, 2016, available at: http://www.hydroquebec.com/publications/en/docs/comparaison-electricity-prices/comp_2016_en.pdf (accessed 5 December 2016), p.4.

[764] United States Department of Energy, *Grid 2030: A National Vision for Electricity's Second 100 Years*, Office of Electric Transmission and Distribution, 2003, available at: https://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/Electric_Vision_Document.pdf (accessed 7 February 2018).

[765] Zhenya Liu, *Global Energy Interconnection* (Amsterdam: Elsevier, 2015), p.207.

4.5. Conclusion

The US case is particularly significant as it accommodates one of the most comprehensive water development systems in the world[766] and became the main source of inspiration for the grand hydraulic works for the most parts of the world.[767] The US borders with Canada in the north and with Mexico in the south and the climate and hydrological situation varies in the north-south direction. Among the numerous water bodies shared with Canada, the Columbia, the Nelson-Saskatchewan, and the Great Lakes are the major river basins, while the Columbia River basin is the most important in terms of hydropower generation and trade. Water scarcity is not a serious issue in the north, while in the south, in the Colorado and the Rio Grande basins, water stress is higher, exacerbated by drought conditions in the western part of North America and the impacts of climate change. The US has an upstream position in all these river basins and the US states in the West have historically been dependent on the large water development projects that lean on the major big rivers here.[768] The definitive feature of the West is water scarcity and the water policies in the western part of the US were designed in accordance. Usually these policies have had impacts on the environment, society, and economy, as well as on the bilateral hydropolitical relations.[769] In order to decrease the water stress in the river basins in the West and to regulate transboundary river basin management principles, IBWC was established and reinforced by the minute process. Within the US, some measures were taken in order to mitigate the impacts of the drought, including the reallocation of water and establishment of water banks. These demand management

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[766] Donald Worster, "Hydraulic Society in California: An Ecological Interpretation," *Agricultural History*, vol. 56, no. 3, 1982, p.506.

[767] F. Molle, P.P. Mollinga & P. Wester, "Hydraulic Bureaucracies and the Hydraulic Mission: Flows of Water, Flows of Power," *Water Alternatives*, vol. 2, no. 3, 2009, p.329.

[768] Robert Morgan, *Water and the Land: A History of American Irrigation* (Fairfax, Virginia: Adams Publishing, 1993), p.1.

[769] Kevin Wehr, *America's Fight over Water: The Environmental and Political Effects of Large-Scale Water Systems* (New York and London: Routledge, 2004), pp.5-6.

measures in the arid Southwest is important and there are some positive developments in terms of the efficiency of water use since the 2000s.

The US case is a demonstration of different hydropolitical and economic outcomes in a single case. The north and south differs not only in terms of precipitation and the importance of agriculture, but also, these two parts differ from each other in terms of economic (electricity) integration and hydropolitical relations. The intensification of the hydropolitical problems in the south may be related to the relatively low level of hydroelectricity trade, other factors, such as the differences between the south and north in terms of climate, geography, hydropower potential, and a conflictual political history often based on economic interests, may have impacts on this phenomenon as well. In order to make a sound analysis, therefore, other cases should also be evaluated in a comparative manner.

CHAPTER V

CHINA

5.1. Introduction

Global water and hydroelectricity sectors witnessed the rise of China since the mid-1990s, challenging the dominant position of the US in waterworks and surpassing it in some aspects. It is true that the steady growth of Chinese hydroelectricity and waterworks sectors are reflections of Chinese economic growth in recent decades. On the other hand, as this chapter discusses, water has long been an indispensable part of Chinese political and economic history.

China has a high number of rivers and streams it shares with its neighbors. In recent decades, it experiences a severe water scarcity problem mainly because of increasing population,[770] and the government of China has plans for the transboundary streams on almost all major rivers, especially in the southern part of the country. Some believe that the food and water problems in China has become so enormous that immediate and radical solutions for these issues should be high on the agenda of Chinese policymakers.[771] Yet, water stress has been increasing and the climate change affects the water situation, especially in the densely populated South and

[770] Yong Jiang, "China's Water Scarcity," *Journal of Environmental Management*, vol. 90, 2009

[771] Claude Arpi, "Diverting the Brahmaputra: Declaration of War?," *The Rediff Special*, 2003, available at: http://www.rediff.com/news/2003/oct/27spec.htm (accessed 17 January 2018).

Southeast Asia, and therefore large dam and diversion projects may cause bilateral political disputes between the riparians.[772]

The proposed dams on the upstream Chinese rivers may disturb the fragile ecosystems and have impacts on a number of aspects, including agriculture, socioeconomic situation of the people, development, international trade, or navigation. On the other hand, the new interconnection projects and electricity export schemes proposed and supported by the Chinese government are seen by some regional governments as the only way for boosting domestic economic growth and prosperity. This chapter discusses the impacts of new dams, hydraulic schemes, and interconnection projects.

5.2. Physical characteristics

China covers a vast territory with large rivers and great basins. The greatest of these are in the eastern part of the country, flowing in the west-east direction as a general trend. The Yellow, the Yangtze, and the Pearl rivers are some examples of these great rivers that flow within the political boundaries of China. Of China's vast territory, about 3.2 million square kilometers are within the catchment zones of nineteen international river basins.[773] The country possesses 6 percent of the world's total freshwater, but these water resources are unevenly distributed across its territory. Only 17 percent of China's total water resources are in the north, while the remaining 83 percent is in the southern part.[774] Two main important characteristics

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[772] Jonathan Holslag, "Assessing the Sino-Indian Water Dispute," *Journal of International Affairs*, vol. 64, no. 2, 2011; For an India-China water wars literature review, see: Hongzhou Zhang, "Sino-Indian Water Disputes: The Coming Water Wars," *WIREs Water*, vol. 3, 2016, pp.156-57. See also: Sudha Ramachandran, "Water Wars: China, India and the Great Dam Rush," *The Diplomat*, 2015, available at: https://thediplomat.com/2015/04/water-wars-china-india-and-the-great-dam-rush (accessed 4 January 2018).

[773] James Nickum, "The Upstream Superpower: China's International Rivers," in O. Varis, C. Tortajada & A.K. Biswas, eds. *Management of Transboundary Rivers and Lakes*, 2008, p.227.

[774] Hongzhou Zhang & Mingjiang Li, "Thirsty China and Its Transboundary Waters," in H. Zhang & M. Li, eds. *China and Transboundary Water Politics in Asia*, 2018, p.3.

of the Chinese international rivers are that about three-fourth of the runoff in China do not flow beyond the political boundaries of the country, and the country has an upstream position in nearly all transboundary rivers.[775]

5.2.1. The rivers in the north

The Tarim basin, or with its Uyghur name Altishahr, is the largest international river basin of China with about one million square kilometers of width. About 95 percent of this vast endorheic basin remains within China, and the rest is in India and in the rugged parts of Kyrgyzstan.[776] The region is covered by the largest and most arid desert of China, the Taklimakan Desert, stretching through the Uyghur Autonomous Region.[777] The desert region remains in the dry and cold desert climate zone, according to the Köppen-Geiger classification.[778] In the north of the desert are the Tien Shan Mountain range and in the south stretches the Kunlun Shan range. The southwest of the basin borders with the disputed borders of China with India and Pakistan. The Tarim River is the name of the mainstream, which is "the longest continental river in the world,"[779] and there are three major tributaries, the

[775] James Nickum, "The Upstream Superpower: China's International Rivers," in O. Varis, C. Tortajada & A.K. Biswas, eds. *Management of Transboundary Rivers and Lakes*, 2008, p.229.

[776] James Nickum, "The Upstream Superpower: China's International Rivers," in O. Varis, C. Tortajada & A.K. Biswas, eds. *Management of Transboundary Rivers and Lakes*, 2008, pp.229-30.

[777] Jiang Leiwen, et al., "Water Resources, Land Exploration and Population Dynamics in Arid Areas - The Case of the Tarim River Basin in Xinjiang of China," *Population and Environment*, vol. 26, no. 6, 2005, p.474.

[778] Markus Kottek, et al., "World Map of the Köppen-Geiger Climate Classification Updated," *Meteorologische Zeitschrift*, vol. 15, no. 3, 2006.

[779] Fan Lianqing Xue, et al., "Identification of Potential Impacts of Climate Change and Anthropogenic Activities on Streamflow Alterations in the Tarim River Basin, China," *Scientific Reports*, vol. 7, no. 8254, 2017, p.1.

Aksu, the Hotan, and the Yarkant rivers. The level of discharge from these tributaries is about 18 cubic kilometers per annum.[780]

In the north, China shares the Amur (Heilong) River basin almost equally with Russia, the Yalu River basin with North Korea, the Tumen River basin with Russia and North Korea, and the Ili and Irtysh River basins with Kazakhstan.[781] China shares the Amur River with Russia in the northeast. The name in of this river in China is the Heilong. The river is about 4,400 kilometers long and its basin covers nearly 2 million square kilometers.[782] The Amur is formed by the confluence of two tributaries, the Shilka from the Russian side, and the Argun River that establishes part of the border between the two countries. Further important tributaries are the Zeya River that joins the mainstream from the left, and the Songhua and the Ussuri rivers from the right. The Amur River flows in the west-east direction, establishes an important part of the boundary between Russia and China, and empties about 364 cubic kilometers of water into the Pacific Ocean annually.[783] The rivers shared with Mongolia are relatively shorter inland streams, the most important of which are the

[780] Jiang Leiwen, et al., "Water Resources, Land Exploration and Population Dynamics in Arid Areas - The Case of the Tarim River Basin in Xinjiang of China," *Population and Environment*, vol. 26, no. 6, 2005, p.478.

[781] James Nickum, "The Upstream Superpower: China's International Rivers," in O. Varis, C. Tortajada & A.K. Biswas, eds. *Management of Transboundary Rivers and Lakes*, 2008, pp.236-39.

[782] According to some sources, the length of the river is about 2,800 kilometers, but with its longest tributary, the Argun (Ergune) river, the length reaches too 4,400 kilometers. See: Stratfor, "Competing Interests on the Mighty Amur River," *Stratfor Worldview*, 2016, available at: https://worldview.stratfor.com/article/competing-interests-mighty-amur-river (accessed 1 January 2018). See also: Amur-Heilong.net, "The Amur-Heilong River Basin," 2017, available at: http://amur-heilong.net/http/01water_chap.html (accessed 5 January 2018).

[783] Amur-Heilong.net, "The Amur-Heilong River Basin," 2017, available at: http://amur-heilong.net/http/01water_chap.html (accessed 5 January 2018).

Halaha River, the Kerulen River, and the Bulgan River.[784] As a general characteristic, the river basins in the north and east flow through less densely populated lands. In contrary, the basins in the south are populated by millions of people.

The Tumen and the Yalu rivers are the shared rivers of China in the northeastern part of the country. The Tumen River, also known as the Duman River, is more than 500 kilometers long and establishes part of the border between China, North Korea and Russia. It has relatively small basin area, which covers about 33 thousand square kilometers, of which about two-thirds is in China.[785] The Yalu River, also known as the Amnok River, is about 800 kilometers long, and its basin is shared by China and North Korea. The total basin area of the river is about 64 thousand square kilometers, about half in China.[786] Both the Yalu and the Tumen rivers rise at about 2,500 meters above sea level near the Paektu Mountain, an active volcano on the boundary between China and North Korea. The Yalu and the Tumen rivers run in opposite directions. The former flows in the northeast-southwest direction, emptying in the Yellow Sea, while the latter runs in the southwest-northeast direction and emptying into the Sea of Japan.

5.2.2. The rivers in the south

In the south of China stretches the Tibetan or the Himalayan Plateau, a vast area of about 2.5 million square kilometers. The west of the plateau is dominated by lakes formed by melting glaciers, and the east of it is famous for its rivers draining melting snow and glaciers towards the Pacific Ocean. The glaciers and permanent snow

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[784] "Agreement between the Government of the People's Republic of China and the Government of Mongolia on the Protection and Utilization of Transboundary Waters" 1994, available at: http://www.ecolex.org/server2neu.php/libcat/docs/TRE/Full/Other/TRE-152454.pdf (accessed 13 November 2017).

[785] Hongzhou Zhang & Mingjiang Li, "Thirsty China and Its Transboundary Waters," in H. Zhang & M. Li, eds. *China and Transboundary Water Politics in Asia*, 2018, p.5.

[786] Hongzhou Zhang & Mingjiang Li, "Thirsty China and Its Transboundary Waters," in H. Zhang & M. Li, eds. *China and Transboundary Water Politics in Asia*, 2018, p.5.

on this plateau, about 5,000 – 5,200 meters above sea level in average,[787] is the headwaters of various rivers in Southeast Asia, including the Mekong, the Salween, the Yangtze, the Brahmaputra, and the Yellow rivers. In Yunnan, in the southeastern edge of the Tibetan plateau, the three major rivers with separate basins, the Salween, the Yangtze and the Mekong flow in parallel valleys.[788] The elevation in the Yunnan province reaches up to 6,740 meters above sea level.[789]

The most important among the transboundary river basins are the Mekong, the Salween, the Irrawaddy, the Ganges-Brahmaputra-Meghna, the Red River, and the Indus River basins. China is the upstream riparian in all these river basins, which it shares with eleven riparian countries, which are Viet Nam, Laos, Myanmar, Cambodia, Thailand, Bangladesh, Bhutan, Nepal, India, Pakistan, and Afghanistan. Almost half of the world's total population lives in these six river basins.[790] Within the vast geography of China, the Mekong River basin covers a relatively small area. It is China's Yunnan province, through which the river flows.[791] The Mekong River basin is the largest in Southeast Asia is with its 800 thousand square kilometers of catchment area. In total, some 165 thousand square kilometers of this basin remains within China, which covers only about 2 percent of Chinese territory. The river

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[787] Peter Adamson, Ian Rutherfurd, Murray Peel & Iwona Conlan, "The Hydrology of the Mekong River," in I. Campbell, ed. *The Mekong*, 2009, p.54.

[788] Salween Watch Coalition, *Current Status of Dams on the Salween River*, 2016, available at: https://www.internationalrivers.org/resources/11286 (accessed 20 April 2017), p.2.

[789] P. Wang, J. Lassoie, S. Dong & S. Morreale, "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*, vol. 117, 2013, p.132.

[790] Mirja Kattelus, et al., "China's Southbound Transboundary River Basins: A Case of Asymmetry," *Water International*, vol. 40, no. 1, 2015, p.113.

[791] Although some include the Guangxi Zhuang Autonomous Region of China into the re-gion, the river basin does not actually cover Guangxi. See: GMS, *Greater Mekong Subregion Atlas of the Environment* (Manila: Asian Development Bank, 2012); Tira Foran, "Impacts of Natural Resource-Led Development on the Mekong Energy System," in A. Smajgl & J. Ward, eds. *The Water-Food-Energy Nexus in the Mekong Region: Assessing Development Strategies Considering Cross-Sectoral and Transboundary Impacts*, 2013.

basin covers 4 percent of Myanmar, 85 percent of Laos, 36 percent of Thailand, 86 percent of Cambodia and 20 percent of Viet Nam.[792] The basin is usually analyzed in two parts, which are the Upper Mekong, which is upstream of the Yunnan, China; and the Lower Mekong, from Yunnan to the South China Sea. While the Upper Mekong is mostly rugged and mountainous, the Lower Mekong basin consists of flood plains suitable for agriculture.[793] The Mekong River has a length of about 4,900 kilometers beginning from southeast China and discharging into the South China Sea (Figure 5.1).[794]

The name of the Mekong River in China is Lancang. The river rises in Tibet Autonomous Region, about 5,200 meters above sea level.[795] The river loses 800 meters of elevation within Chinese territory, and thus the mainstream of the Mekong River is very suitable for constructing cascades of dams.[796] The mainstream of the river is politically important as it establishes parts of the borders between China and Myanmar and between Thailand and Laos, and it draws all the border between Myanmar and Laos.[797]

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[792] Food and Agriculture Organization of the United Nations, *Mekong Basin*, 2011, available at: http://www.fao.org/nr/water/aquastat/basins/mekong/index.stm (accessed 18 April 2017), p.1.

[793] Scott Pearse-Smith, "'Water War' in the Mekong Basin?," *Asia Pacific Viewpoint*, vol. 53, no. 2, 2012, p.149.

[794] Hsing-Chou Sung, "China's Geoeconomic Strategy: Toward the Riparian States of the Mekong Region," in Y. Santasombat, ed. *Impact of China's Rise on the Mekong Region*, 2015, p.29.

[795] Hsing-Chou Sung, "China's Geoeconomic Strategy: Toward the Riparian States of the Mekong Region," in Y. Santasombat, ed. *Impact of China's Rise on the Mekong Region*, 2015, p.29.

[796] P. Wang, J. Lassoie, S. Dong & S. Morreale, "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*, vol. 117, 2013, p.132.

[797] Donald Weatherbee, "Cooperation and conflict in the Mekong River Basin," *Studies in Conflict & Terrorism*, vol. 20, no. 2, 1997, p.168.

Figure 5.1. A map of the Mekong River mainstream[798]

[798] Mekong River Commission, "Interactive Maps," *MRC Data and Information Services*, 2017, available at: http://portal.mrcmekong.org/map_service (accessed 29 April 2017).

As the upstream country, China contributes 16 percent to the Mekong River flow.[799] The Mekong River discharges over 475 cubic kilometers of water into the sea annually, measured at the river mouth near the South China Sea.[800] The Mekong River basin covers slightly more than one-third of the surface area of Southeast Asia.[801] The Lower Mekong is usually classified as hot and humid with 30-38 degree Celsius of average temperature. The precipitation is higher in the highlands of Laos and Cambodia, around 3,000 millimeters annually. The Upper Mekong has the lowest precipitation in the Tibetan Plateau with 600 millimeters of rainfall annually. The Yunnan, on the other hand, receives about 1,700 millimeters of rain.[802] The annual flow regime of the Mekong River is usually divided into the dry season and the wet (flood) season.[803] An important water body in the Lower Mekong is the Tonlé Sap in Cambodia, the largest freshwater lake in the Southeast Asia. This unique water body is connected through the Tonlé Sap River to the Mekong mainstream. In the dry season, the river drains the lake into the Mekong River, shrinking it to less than 2.5 thousand square kilometers. During the floods in the wet season, which begins in late May – early June, the flow directions reverses and the lake reaches a surface area of 15 thousand square kilometers, and a depth of 6 to 9 meters at the peak of the flood season.[804] This seasonal pulse in the lake is crucial for the

[799] Mekong River Commission, "Climate," *Mekong River Commission*, 2010, available at: http://www.mrcmekong.org/mekong-basin/climate/ (accessed 18 April 2017).

[800] Peter Adamson, Ian Rutherfurd, Murray Peel & Iwona Conlan, "The Hydrology of the Mekong River," in I. Campbell, ed. *The Mekong*, 2009, p.54.

[801] Food and Agriculture Organization of the United Nations, *Mekong Basin*, 2011, available at: http://www.fao.org/nr/water/aquastat/basins/mekong/index.stm (accessed 18 April 2017), p.1.

[802] Mekong River Commission, "Climate," *Mekong River Commission*, 2010, available at: http://www.mrcmekong.org/mekong-basin/climate/ (accessed 18 April 2017).

[803] Joakim Ojendal & Kurt Jensen, "Politics and Development of the Mekong River Basin: Transboundary Dilemmas and Participatory Ambitions," in J. Öjendal, S. Hansson & S. Hellberg, eds. *Politics and Development in a Transboundary Watershed: The Case of the Lower Mekong Basin*, 2012, p.38.

[804] Mauricio Arias, *Impacts of Hydrological Alterations in the Mekong Basin to the Tonle Sap Ecosystem*, University of Canterbury, 2013, pp.25-26; Dirk Lamberts, "Little Impact, Much

riverine ecosystem. Another noteworthy water body is the Siphandone Wetlands in Laos, at the border with Cambodia. It is part of the Mekong River, where it splits into many short branches, which confluence back and establish the single mainstream of the Mekong River. This region is highly fertile and suitable for agriculture, dominated by numerous canals and waterfalls and a high number of inhabited and uninhabited islands between these canals.[805]

Table 5-1. Land area of the countries within the Mekong River basin[806]

	Aquastat	**TFDD**	**TWAP**
China	165	171.363	165
Cambodia	155	157.831	154
Laos	202	197.254	206
Myanmar	24	27.581	22
Viet Nam	65	37.986	38
Thailand	184	193.457	188
Total	795	785.472	773

The Salween River, also known as the Thanlwin River, is another important waterway through which the water storage in the Tibetan plateau drains into the ocean.

Damage: The Consequences of Mekong River Flow Alterations for the Tonle Sap Ecosystem," in M. Kummu, M. Keskinen & O. Varis, eds. *Modern Myths of the Mekong: A Critical Review of Water and Development Concepts, Principles and Policies*, 2008, p.4.

805 Giuseppe Daconto, "Introduction: The Siphandone Wetlands," in G. Daconto, ed. *Siphandone Wetlands*, 2001, pp.1-2.

806 In thousand square kilometers. The sources in respective order: Aquastat: Food and Agriculture Organization of the United Nations, *Mekong Basin*, 2011, available at: http://www.fao.org/nr/water/aquastat/basins/mekong/index.stm (accessed 18 April 2017); TFDD: Oregon State University, "Mekong Basin," *Transboundary Freshwater Dispute Database*, 2009, available at: http://gis.nacse.org/tfdd/map/result.php?bcode=MEKO (accessed 25 April 2017); TWAP: UNEP/GEF, "TWAP," *Transboundary Waters Assessment Programme*, 2017, available at: http://www.geftwap.org/twap-project (accessed 18 April 2017).

The river flows undammed through China, Myanmar, and Thailand. Today, at least fifteen dams are planned to be built on this river by the government of Myanmar and China by 2016.[807] The river is about 3,700 kilometers long, second only to the Mekong River in terms of length.[808] The mainstream flows towards the southeast of the Gulf of Martaban. The Salween River basin is 324 thousand square kilometers in total and slightly more than half is in China, while only 5 percent is in Thailand, and the remaining in Myanmar. The river establishes part of the border between Myanmar and Thailand. The major tributaries of the river are the Nam Ma and the Nam Hka that join the mainstream from the east, while the Nam Teng and the Nam Pawn join the mainstream Salween from the western side.[809]

The longest river in Asia, the Yangtze, also originates from the glaciers in the eastern part of the Tibetan plateau and drains into the East China Sea. The largest installed capacity HPP in the world, the Three Gorges Dam, is on the Yangtze River. The river basin is about 1.8 million square kilometers and home of one of every three Chinese citizens. The basin is of utmost importance to the growing Chinese economy.

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[807] Michael Buckley, "The Price of Damming Tibet's Rivers," *The New York Times*, 2015, available at: https://www.nytimes.com/2015/03/31/opinion/the-price-of-damming-tibets-rivers.html?_r=0 (accessed 20 April 2017); Salween Watch Coalition, *Current Status of Dams on the Salween River*, 2016, available at: https://www.internationalrivers.org/resources/11286 (accessed 20 April 2017), p.2.

[808] Food and Agriculture Organization of the United Nations *Salween Basin*, 2011, available at: http://www.fao.org/nr/water/aquastat/basins/salween/index.stm (accessed 23 April 2017).

[809] International Finance Corporation; Ministry of Electricity and Energy; Myanmar Ministry of Natural Resources and Environmental Conservation, *Strategic Environmental Assessment of the Hydropower Sector in Myanmar*, IFC, 2017, available at: http://www.ifc.org/wps/wcm/connect/industry_ext_content/ifc_external_corporate_site/hydro+advisory/resources/sea+of+the+hydropower+sector+in+myanmar+resources+page (accessed 4 January 2018), p.55.

Table 5-2. Land area of the countries within the Salween River basin[810]

	Aquastat	TFDD	TWAP
China	169,6	127,667	137
Myanmar	134,4	106,746	109
Thailand	16	9,062	19
Total	320	243,475	265

The Irrawaddy River, also known as the Ayeyarwady River, is another important river in Southeast Asia, shared by China and Myanmar. The river is about 2,200 kilometers long and its basin covers an area of 413.7 thousand square kilometers.[811] In the upstream, the river is formed with the confluence of two main streams, the Mali Hka and the N'Mai Hka rivers. These rivers confluence at Myitsone, the proposed site for a controversial Chinese giant dam.[812] The river flows in the north-south direction and empties into the Andaman Sea. In the middle part of the

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[810] In thousand square kilometers. The sources in respective order: Aquastat: Food and Agriculture Organization of the United Nations *Salween Basin*, 2011, available at: http://www.fao.org/nr/water/aquastat/basins/salween/index.stm (accessed 23 April 2017); TFDD: Oregon State University, "Salween Basin," *Transboundary Freshwater Dispute Database*, 2009, available at: http://gis.nacse.org/tfdd/map/result.php?bcode=SALW (accessed 20 April 2017); TWAP: UNEP/GEF, "TWAP," *Transboundary Waters Assessment Programme*, 2017, available at: http://www.geftwap.org/twap-project (accessed 18 April 2017).

[811] International Finance Corporation; Ministry of Electricity and Energy; Myanmar Ministry of Natural Resources and Environmental Conservation, *Strategic Environmental Assessment of the Hydropower Sector in Myanmar*, IFC, 2017, available at: http://www.ifc.org/wps/wcm/connect/industry_ext_content/ifc_external_corporate_site/hydro+advisory/resources/sea+of+the+hydropower+sector+in+myanmar+resources+page (accessed 4 January 2018), p.23.

[812] International Finance Corporation; Ministry of Electricity and Energy; Myanmar Ministry of Natural Resources and Environmental Conservation, *Strategic Environmental Assessment of the Hydropower Sector in Myanmar*, IFC, 2017, available at: http://www.ifc.org/wps/wcm/connect/industry_ext_content/ifc_external_corporate_site/hydro+advisory/resources/sea+of+the+hydropower+sector+in+myanmar+resources+page (accessed 4 January 2018), p.26. See: Qin Hui, "Behind Myanmar's Suspended Dam (1)," *Chinadialogue*, 2012, available at: https://www.chinadialogue.net/article/show/single/en/4832 (accessed 12 January 2018).

Irrawaddy River basin, some tributaries reach to the mainstream from China. These are the Namtabak River, regulated by a total of 19 dams on Chinese side, the Dapein River, trapped by 18 dams as of 2017, and the Shweli River basin with a total of 11 dams.[813]

China shares the Indus, the Brahmaputra, the Kosi and the Ghaghara rivers with its neighbors in the south.[814] In South Asia, the most important transboundary river system, of which China is an important part, is the Ganges-Brahmaputra-Meghna River basin, covering more than 1.7 million square kilometers. The system is established by the confluence of the three rivers in Bangladesh, and as some have observed, the three main tributaries flow through very distinct geographical and socioeconomical regions in Southeast Asia.[815] The mouth of the river system, the largest delta in the world,[816] is at the Indian Ocean, the Bay of Bengal.[817] The headwaters of the Ganges and the Brahmaputra are in the Himalayas. The Ganges River basin is slightly wider than 1 million square kilometers, most of which is India, while only 33,500 square kilometers (3 percent) is within Chinese borders. On the other hand, about half of the 540 thousand square kilometers Brahmaputra

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[813] International Finance Corporation; Ministry of Electricity and Energy; Myanmar Ministry of Natural Resources and Environmental Conservation, *Strategic Environmental Assessment of the Hydropower Sector in Myanmar*, IFC, 2017, available at: http://www.ifc.org/wps/wcm/connect/industry_ext_content/ifc_external_corporate_site/hydro+advisory/resources/sea+of+the+hydropower+sector+in+myanmar+resources+page (accessed 4 January 2018), pp.37-40.

[814] Hongzhou Zhang, "Sino-Indian Water Disputes: The Coming Water Wars," *WIREs Water*, vol. 3, 2016.

[815] Asit Biswas, "Management of Ganges-Brahmaputra-Meghna System: Way Forward," in O. Varis, C. Tortajada & A.K. Biswas, eds. *Management of Transboundary Rivers and Lakes*, 2008.

[816] Sudha Ramachandran, "Water Wars: China, India and the Great Dam Rush," *The Diplomat*, 2015, available at: https://thediplomat.com/2015/04/water-wars-china-india-and-the-great-dam-rush (accessed 4 January 2018).

[817] Food and Agriculture Organization, *Irrigation in Southern and Eastern Asia in Figures*, Aquastat, 2011, available at: http://www.fao.org/docrep/016/i2809e/i2809e.pdf (accessed 16 January 2018), p.111.

River basin is in the southern part of China.[818] In the Chinese part of the Brahmaputra River basin flows the Yarlung Zangbo River, which originates from the southern Tibetan Plateau, north of Nepal, getting most of its water from tens of glacial lakes and permanent snow near Mount Kailash and Angsi Glacier.[819] The 1,600 kilometers-long Yarlung Zangbo flows roughly in the west-east direction through the southern Tibetan Plateau towards the northeast of the Arunachal Pradesh. The river then turns to south at the famous “Great Bend” or the “Shuomatan Point”[820] and gets the name Brahmaputra in the northeastern part of India. The Yarlung Zangbo is estimated to carry about 165.4 cubic kilometers of water from China towards India.[821] The Brahmaputra flows towards southeast in Indian territory, enters Bangladesh from the northeast, gets the name Jamuna, travels south until it merges with the Meghna River. The total runoff of the Ganges-Brahmaputra-Meghna River system is estimated to be about 1,350 cubic kilometers per year.[822]

[818] For detailed information, see: Muhammad Masood, Naota Hanasaki & Kuniyoshi Takeuchi, "Model Study of the Impacts of Future Climate Change on the Hydrology of Ganges–Brahmaputra–Meghna Basin," *Hydrology and Earth System Sciences*, vol. 19, 2015; Food and Agriculture Organization, *Irrigation in Southern and Eastern Asia in Figures*, Aquastat, 2011, available at: http://www.fao.org/docrep/016/i2809e/i2809e.pdf (accessed 16 January 2018), p.111.

[819] Nilanjan Ghosh, "China Cannot Rob Us of Brahmaputra," *The Hindu Business Line*, 2017, available at: http://www.thehindubusinessline.com/opinion/brahmaputra-river-india-china-water-dispute-people/article9974000.ece (accessed 12 January 2018).

[820] Sudha Ramachandran, "Water Wars: China, India and the Great Dam Rush," *The Diplomat*, 2015, available at: https://thediplomat.com/2015/04/water-wars-china-india-and-the-great-dam-rush (accessed 4 January 2018).

[821] Golam Rasul, "Water for Growth and Development in the Ganges, Brahmaputra, and Meghna Basins: An Economic Perspective," *Intl. J. River Basin Management*, vol. 13, no. 3, 2015, p.388.

[822] Golam Rasul, "Water for Growth and Development in the Ganges, Brahmaputra, and Meghna Basins: An Economic Perspective," *Intl. J. River Basin Management*, vol. 13, no. 3, 2015, p.389.

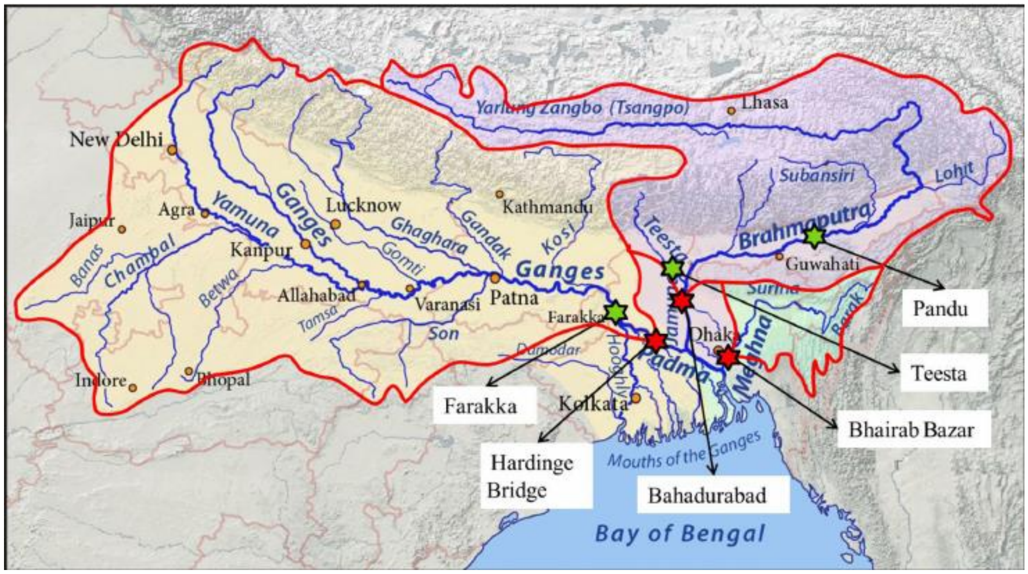

Figure 5.2. The Ganges-Brahmaputra-Meghna River system[823]

5.2.3. Local institutions and regulations

China voted against the UN Water Convention of 1997. This was perceived as a sign of Chinese reluctance of cooperation in transboundary river basins, in most of which it is in the upstream position and depends only 0.6 percent on the streams from its neighbors.[824] As China refrained from signing the 1997 Water Convention, some authors argue that this is an indicator of China's is unwillingness for regional collaboration regarding transboundary water issues,[825] and claim that Chinese au-

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[823] Muhammad Masood, Naota Hanasaki & Kuniyoshi Takeuchi, "Model Study of the Impacts of Future Climate Change on the Hydrology of Ganges–Brahmaputra–Meghna Basin," *Hydrology and Earth System Sciences*, vol. 19, 2015, p.750.

[824] James Nickum, "The Upstream Superpower: China's International Rivers," in O. Varis, C. Tortajada & A.K. Biswas, eds. *Management of Transboundary Rivers and Lakes*, 2008, pp.230-31.

[825] Jonathan Chenoweth, Hector Malano & Juliet Bird, "Integrated River Basin Management in the Multijurisdictional River Basins: The Case of the Mekong River Basin," *International Journal of Water Resources Development*, vol. 17, no. 3, 2001, p.368.

thorities aim at keeping water development projects within Chinese territory as issues of internal politics.[826] In recent years, however, this situation tends to change as there is an increasing pressure on China to reassess its transboundary water policies, especially from its neighbors, who are being steadily affected by Chinese unilateral actions on transboundary waters.[827]

On the other hand, with some neighbors, China signed bilateral water agreements. One of them was on the protection and utilization of transboundary waters signed with Mongolia in 1994.[828] The agreement aims to protect the ecosystem and fisheries in the shared river basins, reduce pollution, and ensure an equitable and fair use of waters from the rivers. Also, a Joint Committee on Transboundary Waters was established between the two signatories to observe the implementation of the agreement.[829]

Although China has been reluctant to join, the most comprehensive and serious international organizations in Southeast Asia cover the Mekong River and its catchment zone. Four of the six Mekong River basin countries established the Mekong River Commission (MRC) in 1995 with the Mekong Agreement,[830] supported by major international organizations such as the World Bank and the ADB. There are

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[826] Scott Pearse-Smith, "'Water War' in the Mekong Basin?," *Asia Pacific Viewpoint*, vol. 53, no. 2, 2012, p.153.

[827] Hongzhou Zhang & Mingjiang Li, "Thirsty China and Its Transboundary Waters," in H. Zhang & M. Li, eds. *China and Transboundary Water Politics in Asia*, 2018, p.4 and 8.

[828] "Agreement between the Government of the People's Republic of China and the Government of Mongolia on the Protection and Utilization of Transboundary Waters" 1994, available at: http://www.ecolex.org/server2neu.php/libcat/docs/TRE/Full/Other/TRE-152454.pdf (accessed 13 November 2017).

[829] "Agreement between the Government of the People's Republic of China and the Government of Mongolia on the Protection and Utilization of Transboundary Waters" 1994, available at: http://www.ecolex.org/server2neu.php/libcat/docs/TRE/Full/Other/TRE-152454.pdf (accessed 13 November 2017).

[830] "Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin" 1995, available at: www.mrcmekong.org/assets/Publications/policies/agreement-Apr95.pdf (accessed 18 October 2017).

three permanent bodies established according to the regulations foreseen in the agreement, the Council, the Joint Committee, and the Secretariat. The countries are represented at ministerial level in the Council, while the Joint Committee is composed of bureaucrats from technical backgrounds.[831] In the annual meetings of the commission, ministers of water and environment convene to discuss basin management issues.[832] The total surface area of the MRC countries cover about three quarters of the Mekong basin area. The absence of Myanmar in the commission is perceived not that significant due to its relatively lower share in the basin surface area and marginal contribution to the river flow. However, the absence of China is a significant setback for the proper functioning of the commission and extensive cooperation among the basin countries considering China's economic growth and grand hydraulic schemes in the basin.

On the other hand, China closely cooperates with the MRC and shares hydrological data from Yunnan province on a regular basis.[833] The MRC collects data of water quality and quantity, sedimentation, evaporation, precipitation, and other necessary parameters from various monitoring stations in the member states. However, the reliability of water quality data and measurement are doubtful.[834] In general, inte-

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[831] Ashok Swain, "Politics or Development: Sharing of International Rivers in the South," in J. Öjendal, S. Hansson & S. Hellberg, eds. *Politics and Development in a Transboundary Watershed: The Case of the Lower Mekong Basin*, 2012, p.27.

[832] Mekong River Commission, "Governance and Organisational Structure," *Mekong River Commission*, n.d., available at: http://www.mrcmekong.org/about-mrc/governance-and-organisational-structure/ (accessed 20 April 2017).

[833] Ashok Swain, "Politics or Development: Sharing of International Rivers in the South," in J. Öjendal, S. Hansson & S. Hellberg, eds. *Politics and Development in a Transboundary Watershed: The Case of the Lower Mekong Basin*, 2012, p.27.

[834] Jonathan Chenoweth, Hector Malano & Juliet Bird, "Integrated River Basin Management in the Multijurisdictional River Basins: The Case of the Mekong River Basin," *International Journal of Water Resources Development*, vol. 17, no. 3, 2001, p.370.

grated water resources management could not be achieved due to institutional setbacks, lack of organizational and technical capacity and political problems.[835] The commission could not even find a satisfactory solution to one of the core issues, the question of water allocation.[836] Although it could not solve the technical water-related issues, as Bobekova et al. argue from the liberal institutionalist perspective, the MRC contributed to the establishment and maintenance of peace in the East Asia to a significant degree.[837] On the other hand, it is also criticized on the ground that it ignores "crucial hydrological and ecological aspects of the Mekong's identity."[838] The aims of the 1995 Mekong Agreement contradicts with the degraded status of the ecology and hydrology of the Mekong River basin caused by the large-scale development projects, leaning on the cooperative framework envisaged by the 1995 Agreement itself.[839] In the 2000s, as the development aims of the less developed countries in the Lower Mekong Basin proliferated, the MRC was seen "as more a hindrance than a help" for the development projects of the individual countries, such as Viet Nam, Cambodia, and Laos.[840] In the years when it was first established, the Mekong Committee was the largest and most comprehensive river

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[835] Ian Campbell, "The Challenges for Mekong River Management," in I. Campbell, ed. *The Mekong: Biophysical Environment of an International River Basin* 1st ed., 2009, p.416.

[836] Jonathan Chenoweth, Hector Malano & Juliet Bird, "Integrated River Basin Management in the Multijurisdictional River Basins: The Case of the Mekong River Basin," *International Journal of Water Resources Development*, vol. 17, no. 3, 2001, pp.374-75.

[837] Elvira Bobekova, Scott Pearse-Smith & Isak Svensson, "Rivers of Peace: Institutionalised Mekong River Cooperation and the East Asian Peace," *European Journal of East Asian Studies*, vol. 12, 2013.

[838] Chris Sneddon & Coleen Fox, "Rethinking Transboundary Waters: A Critical Hydropolitics of the Mekong Basin," *Political Geography*, vol. 25, no. 2, 2006, p.189.

[839] Chris Sneddon & Coleen Fox, "Rethinking Transboundary Waters: A Critical Hydropolitics of the Mekong Basin," *Political Geography*, vol. 25, no. 2, 2006, p.197.

[840] World Bank / Asian Development Bank, *Mekong Water Resources Assistance Strategy*, WB/ADB, 2006, p.6.

basin cooperation body in the region.[841] But the influence and importance of the Committee was reduced significantly after the establishment of the GMS. In 1995, the former members of the Committee founded the Mekong River Commission (MRC) with an agreement known as the Mekong Agreement, which aimed at protecting environment and establish a cooperative atmosphere between the riparians.[842]

China joined in various other multinational programs, such as the Greater Mekong Subregion Program (GMS) of the Asian Development Bank (ADB) and the Mekong Basin Development Cooperation of the Association of Southeast Asian Nations (ASEAN).[843] Six countries are involved in the former, the GMS, which was initiated in 1992 to facilitate economic relations among the basin states.[844] This initiative was supported and "dominated" by Japan.[845] The GMS established working groups on agriculture (established in 2002), energy, environment, tourism, trade, and other areas.[846] The latter, the Mekong Basin Development Cooperation of ASEAN, was established in 1996 and meets annually. The aim of this group is

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[841] Mekong River Commission, "History," *Mekong River Commission*, n.d., available at: http://www.mrcmekong.org/about-mrc/history/ (accessed 20 April 2017).

[842] "Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin" 1995, available at: http://www.mrcmekong.org/assets/Publications/policies/agreement-Apr95.pdf (accessed 25 April 2017).

[843] Evelyn Goh, China in the Mekong River Basin: The Regional Security Implications of Resource Development on the Lancang Jiang, Nanyang Technological University, 2004, p.8.

[844] Asian Development Bank, "Overview of the Greater Mekong Subregion," *ADB*, 2017, available at: https://www.adb.org/countries/gms/overview (accessed 24 April 2017).

[845] Chris Sneddon & Coleen Fox, "Rethinking Transboundary Waters: A Critical Hydropolitics of the Mekong Basin," *Political Geography*, vol. 25, no. 2, 2006, p.187.

[846] Asian Development Bank, "GMS Sector Activities," *ADB*, 2017, available at: https://www.adb.org/countries/gms/sector-activities (accessed 24 April 2017).

achieving sustainable economic development and facilitating economic ties among the basin states.[847]

Another organization worth noting is the Mekong Programme on Water, Environment, and Resilience (M-POWER). It is a network of people from Cambodia, China, Laos, Myanmar, Thailand and Viet Nam. M-POWER aims for "improved livelihood security and human and ecosystem health in the Mekong region."[848] The organization is supported by the UN agency organization International Fund for Agricultural Development, the government of France, and the Consultative Group on International Agricultural Research.[849]

5.3. Water development projects in China

The earliest traces of Chinese agriculture date back to around 7,000 BC to the Central Plain in the Yellow (Huang He) River valley, also known as Zhongyuan, in today's Henan province of China.[850] Millet was produced through a primitive form of irrigation and wheat was imported from the western parts of Asia around the end of the second millennium BC.[851] A large-scale irrigation network with canals was introduced by the Qin rulers between the Yellow and Yangtze (Chang Jiang) rivers

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847 ASEAN-Mekong Basin Development Cooperation, *The 14th Ministerial Meeting of the ASEAN-Mekong Basin Development Cooperation*, ASEAN-Mekong Basin Development Cooperation (AMBDC), 2012, available at: http://www.asean.org/storage/images/documents/Joint%20Media%20Statement%2014th%20AMBDC%20Ministerial%20Meeting%20-%2029%20August%202012%20(final)%201.pdf (accessed 17 April 2017).

848 Molle, F., Foran, T. & Käkönen, M., eds., *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance* (London, Sterling: Earthscan, 2009).

849 Molle, F., Foran, T. & Käkönen, M., eds., *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance* (London, Sterling: Earthscan, 2009).

850 Richard Glahn, *The Economic History of China: From Antiquity to the Nineteenth Century* (Cambridge: Cambridge University Press, 2016), pp.chapter no. 1 (The Bronze Age Economy), section: Production and Labor.

851 Richard Glahn, *The Economic History of China: From Antiquity to the Nineteenth Century* (Cambridge: Cambridge University Press, 2016), pp.chapter no. 1 (The Bronze Age Economy), section: Production and Labor.

in the third century BC. The Zheng Guo Canal was a major example, through which about 180 thousand hectares of land was irrigated.[852] Other examples were the Dujiangyan Canal[853] and the Lingqu Canal, both built in the third century BC, with the intentions of flood control and navigation. Through the irrigation of about 800 thousand hectares of land provided by the water from the Dujiangyan Canal, agriculture in the Chengdu plain in Sichuan was so developed that it is argued that the Qin dynasty, the members of which would become the first emperors of China, relied upon this agricultural activity to sustain wealth and power.[854] In the Mekong Delta, at Long Xuyen in today's Viet Nam, irrigation canals date back to 300 BC and 700 AD.[855] During the Han dynasty, large irrigation schemes made higher yields and cultivation of cereals, such as wheat and barley, possible in the arid regions in the north, in Guanzhong and in the Central Plain, and of rice in the south, on the Shaoxing plain in the south of the Hangzhou bay.[856] The network of the biggest and most famous of the many irrigation and transport facilities constructed by the Chinese is known as the Grand Canal, which connected the capital of the Sui

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[852] Richard Glahn, *The Economic History of China: From Antiquity to the Nineteenth Century* (Cambridge: Cambridge University Press, 2016), pp.chapter no. 2 (From City-State to Autocratic Monarchy), section: Economic Transformation in the Dawning Iron Age.

[853] Colin Green, *Handbook of Water Economics: Principles and Practice* (W.Sussex: John Wiley & Sons, 2003), p.288.

[854] World Commission on Dams, *Dams and Development: A New Framework for Decision-Making* (London and Sterling: Earthscan, 2000), p.8; Richard Glahn, *The Economic History of China: From Antiquity to the Nineteenth Century* (Cambridge: Cambridge University Press, 2016), pp.chapter no. 2 (From City-State to Autocratic Monarchy), section: Economic Transformation in the Dawning Iron Age.

[855] David Biggs, Fiona Miller, Chu Hoanh & François Molle, "The Delta Machine: Water Management in the Vietnamese Mekong Delta in Historical and Contemporary Perspectives," in F. Molle, T. Foran & M. Kakönen, eds. *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance*, 2009, p.206.

[856] Richard Glahn, *The Economic History of China: From Antiquity to the Nineteenth Century* (Cambridge: Cambridge University Press, 2016), pp.chapter no. 4 (Magnate Society and the Estate Economy), section: Agricultural Transformation in the Han Period.

dynasty with the grain producing regions. Also, it connected two great rivers, the Yangtze and the Yellow, and facilitated the exchange of products, wheat and rice.[857]

During the course of time, the majority of the Chinese people moved to the south, into more humid and fertile rice producing areas.[858] Rice required much more labor and investments, and at the same time, it generated far more yields than wheat and millet cultivation. The prosperity contributed a rapid rise in the population. Rice harvest was made through reclamation of marshes on the Yangtze River delta and terracing. Drainage became the most significant hydraulic work under water abundance.[859] But this resulted in gradual deforestation, degradation of soil, and an alteration of the balances of the ecosystem.[860]

Because of geographical, climatic and environmental factors, the Chinese specialized in the course of history not only in the building of irrigation systems, but also in other sophisticated hydraulic works such as dikes, levees, seawalls, sluices, drainage systems, and navigable water canals.[861] The Chinese population became so dependent on waterworks that in the fifteenth century Beijing relied on supplies

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[857] Richard Glahn, *The Economic History of China: From Antiquity to the Nineteenth Century* (Cambridge: Cambridge University Press, 2016), pp.chapter no. 5 (The Chinese-nomad synthesis and the reunification of the empire).

[858] This is labeled as the “medieval economic revolution” by Elvin. See: Mark Elvin, *The Retreat of the Elephants: An Environmental History of China* (London and New Haven: Yale University Press, 2008), p.7.

[859] Richard Glahn, *The Economic History of China: From Antiquity to the Nineteenth Century* (Cambridge: Cambridge University Press, 2016), pp.chapter no. 6 (Economic Transformation in the Tang-Song Transition).

[860] Mark Elvin, *The Retreat of the Elephants: An Environmental History of China* (London and New Haven: Yale University Press, 2008), p.7.

[861] Mark Elvin, *The Retreat of the Elephants: An Environmental History of China* (London and New Haven: Yale University Press, 2008), p.116.

that arrived through the Grand Canal, the maintenance of which required intense labor and large funds.[862]

In the seventeenth century, when the Russians first appeared in the north around the Amur River basin, they saw the opportunity to reach towards the ocean through the river, but they were not able to control the river basin well until the 1800s. In the mid-nineteenth century, the Russian Empire annexed part of northern China and set the Amur River as the formal boundary between the countries.[863]

5.3.1. Cooperation and competition in water development

In the end of the sixteenth century, the first Portuguese mercenaries appeared in the Pacific, near Burma, and beginning from the seventeenth century, French missionaries and explorers arrived at Indochina. Under the French rule, population in the Mekong delta rose steadily with increasing agricultural activity through the help of new dredging technologies.[864] The French water engineers tried enabling navigation into the Chinese territory through the Mekong River, which was interrupted by the geographical barriers such as the Khone Falls at the Siphandone Wetlands.[865] Later on, with the involvement of the Europeans and Americans, some cooperation and development efforts in the water sector prevailed in the Mekong River basin in the twentieth century. The establishment of the Mekong Consultative Committee with the encouragement of the French colonizers in the late 1940s was an example. Established by Viet Nam, Cambodia, and Laos, the committee was evolved into the

[862] Mark Elvin, *The Retreat of the Elephants: An Environmental History of China* (London and New Haven: Yale University Press, 2008), pp.130-31.

[863] Sue Davis, *The Russian Far East: The Last Frontier?* (London and New York: Routledge, 2003), pp.8-12.

[864] David Biggs, Fiona Miller, Chu Hoanh & François Molle, "The Delta Machine: Water Management in the Vietnamese Mekong Delta in Historical and Contemporary Perspectives," in F. Molle, T. Foran & M. Kakönen, eds. *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance*, 2009, p.207.

[865] Giuseppe Daconto, "Siphandone Wetlands: An Overview," in G. Daconto, ed. *Siphandone Wetlands*, 2001, pp.16-17.

Provisional Mekong Committee in 1954.[866] In 1955, the US government sent representatives from the USBR to the region with a mission of studying possible water development projects.[867]

In 1957, with the encouragement of the UN, the Committee for Coordination of Investigations on the Lower Mekong Basin (known as the Mekong Committee) was established among Thailand, Cambodia and South Vietnam.[868] The committee got under the US influence in a short while as more than one-third of its funding was provided by the Americans.[869] One of the major aims of the committee was generating water data that may be used for developing large scale HPP projects in the Lower Mekong basin. The USBR and the Army Corps of Engineers took active part in the activities of the Committee.[870] The first plans of the Committee involved the construction of a cascade of dams downstream of the Chinese border.[871] Initially,

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[866] Qi Gao, A Procedural Framework for Transboundary Water Management in the Mekong River Basin: Shared Mekong for a Common Future (Leiden, Boston: Martinus Nijhoff Publishers, 2014), p.42.

[867] François Molle, Tira Foran & Philippe Floch, "Introduction: Changing Waterscapes in the Mekong Region – Historical Background and Context," in F. Molle, T. Foran & M. Käkönen, eds. *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance*, 2009, p.4.

[868] Mekong River Commission, "History," *Mekong River Commission*, n.d., available at: http://www.mrcmekong.org/about-mrc/history/ (accessed 20 April 2017); Donald Weatherbee, "Cooperation and conflict in the Mekong River Basin," *Studies in Conflict & Terrorism*, vol. 20, no. 2, 1997, p.170.

[869] Qi Gao, *A Procedural Framework for Transboundary Water Management in the Mekong River Basin: Shared Mekong for a Common Future* (Leiden, Boston: Martinus Nijhoff Publishers, 2014), p.42; François Molle, Tira Foran & Philippe Floch, "Introduction: Changing Waterscapes in the Mekong Region – Historical Background and Context," in F. Molle, T. Foran & M. Käkönen, eds. *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance*, 2009, p.6.

[870] Jeffrey Jacobs, "The United States and the Mekong Project," *Water Policy*, vol. 1, no. 6, 2000, p.589; Carl Middleton, Jelson Garcia & Tira Foran, "Old and new hydropower players in the Mekong region: Agendas and strategies," in F. Molle, T. Foran & M. Käkönen, eds. *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance*, 2009, p.26.

[871] David Biggs, Fiona Miller, Chu Hoanh & François Molle, "The Delta Machine: Water Management in the Vietnamese Mekong Delta in Historical and Contemporary Perspectives," in F.

seven large dams with HPPs were envisioned by the Committee. The reservoirs of these dams would hold about one third of the total annual flow of the Mekong River and the total installed capacity of the HPPs would reach to 23.3 gigawatts.[872]

Chinese water engineering efforts intensified after the mid-twentieth century as well. The number of the dams in China before 1949 was 22.[873] In the late 1950s, as part of the Chinese government's "Great Leap Forward" policy, some big HPP projects were initiated with the support of the Soviet engineers. In these years, dam building efforts in China intensified. One example was the Sanmenxia Dam, completed in 1960, the construction of which led to the displacement of some 400 thousand people.[874] The project was manifested as a monument of development in China, but it caused floods and the electricity generation was not as high as expected.[875] At the same time, under the Cold War atmosphere, the US was trying to influence the region by implementing the Tennessee Valley Authority model into

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Molle, T. Foran & M. Kakönen, eds. *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance*, 2009, p.208.

[872] Carl Middleton, Jelson Garcia & Tira Foran, "Old and new hydropower players in the Mekong region: Agendas and strategies," in F. Molle, T. Foran & M. Käkönen, eds. *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance*, 2009, p.26.

[873] World Commission on Dams, *Dams and Development: A New Framework for Decision-Making* (London and Sterling: Earthscan, 2000), p.9.

[874] F. Molle, P.P. Mollinga & P. Wester, "Hydraulic Bureaucracies and the Hydraulic Mission: Flows of Water, Flows of Power," *Water Alternatives*, vol. 2, no. 3, 2009, p.334.

[875] Probe International, "Introduction to Xie Chaoping's book, "The Great Relocation"," *Probe International*, 2010, available at: https://journal.probeinternational.org/2010/10/15/introduction-to-xie-chaoping%E2%80%99s-book-%E2%80%9Cthe-great-relocation%E2%80%9D/ (accessed 3 September 2017).

the Mekong River basin management schemes.[876] Some Chinese water development projects in the Himalayas in the 1960s caused political dispute between China and India.[877]

In the 1950s, in parallel with the efforts of the US in the basin, the UN Economic Commission for Asia and the Far East (ECAFE)[878] began studying the Mekong River basin for water development projects. The UN was in favor of large scale regional development projects, while the US supported projects on national level.[879] The ECAFE report recommended the building of five key dams, which were Pa Mong, Khemerat, Khone Falls, Sambor, and Tonle Sap.[880] The basin countries supported the ECAFE plan, known as the Mekong Project, for varying political and strategic purposes. This regional framework of the ECAFE set the groundwork for the establishment of the Mekong Committee.[881]

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[876] F. Molle, P.P. Mollinga & P. Wester, "Hydraulic Bureaucracies and the Hydraulic Mission: Flows of Water, Flows of Power," *Water Alternatives*, vol. 2, no. 3, 2009, p.335.

[877] Jonathan Holslag, "Assessing the Sino-Indian Water Dispute," *Journal of International Affairs*, vol. 64, no. 2, 2011, pp.19-20.

[878] See: François Molle, Tira Foran & Philippe Floch, "Introduction: Changing Waterscapes in the Mekong Region – Historical Background and Context," in F. Molle, T. Foran & M. Käkönen, eds. *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance*, 2009, p.4.

[879] Jeffrey Jacobs, "The United States and the Mekong Project," *Water Policy*, vol. 1, no. 6, 2000, p.590.

[880] François Molle, Tira Foran & Philippe Floch, "Introduction: Changing Waterscapes in the Mekong Region – Historical Background and Context," in F. Molle, T. Foran & M. Käkönen, eds. *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance*, 2009, p.4.

[881] Blake Ratner, "The Politics of Regional Governance in the Mekong River Basin," *Global Change Peace & Security*, vol. 15, no. 1, 2003, p.66; Jeffrey Jacobs, "The United States and the Mekong Project," *Water Policy*, vol. 1, no. 6, 2000, p.590.

During the years of the Cold War, Thailand, in particular, received financial and military aid from the US.[882] The US also helped Thailand to build dams to develop the rural and poor regions, especially in the northern part of the country by supplying them with electricity and improved irrigation.[883] One example was the Bhumibol Dam, which was opened in 1964. Laos also got support from the West. The World Bank and the ADB were active in the region in the 1950s and the 1960s. The Mekong Committee and the World Bank supported the efforts for the construction of the first large HPP in Laos, the Nam Ngum 1 Dam.[884] In 1966, David E. Lilienthal (1899-1981), one of the most famous directors of the Tennessee Valley Authority in the US, was sent to the region in order to cooperate with the Vietnamese authorities in their endeavors of developing the Mekong River delta. But the threat of military conflict hindered this cooperation in Viet Nam.[885]

The efforts of the Mekong Committee intensified in the 1970s. It recommended the building of four dams on the mainstream Mekong, including the Tonle Sap Dam, which will cost about 10 billion US dollars. In return, the Soviet Union supported Viet Nam, which began the construction of the giant Hoa Binh Dam by 1979. This

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[882] Chris Sneddon & Coleen Fox, "Rethinking Transboundary Waters: A Critical Hydropolitics of the Mekong Basin," *Political Geography*, vol. 25, no. 2, 2006, p.185; François Molle, Tira Foran & Philippe Floch, "Introduction: Changing Waterscapes in the Mekong Region – Historical Background and Context," in F. Molle, T. Foran & M. Käkönen, eds. *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance*, 2009, p.4.

[883] Ngo Vinh, "KLCM: Sucking Blood from Earth – Thailand Diverts the Mekong River and Threatens Its Water Security," *Mekong Eye*, 2016, available at: https://www.mekongeye.com/2016/11/15/klcm-sucking-blood-from-earth-thailand-diverts-the-mekong-river-and-threatens-its-water-security/ (accessed 18 June 2017).

[884] François Molle, Tira Foran & Philippe Floch, "Introduction: Changing Waterscapes in the Mekong Region – Historical Background and Context," in F. Molle, T. Foran & M. Käkönen, eds. *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance*, 2009, p.5.

[885] David Biggs, Fiona Miller, Chu Hoanh & François Molle, "The Delta Machine: Water Management in the Vietnamese Mekong Delta in Historical and Contemporary Perspectives," in F. Molle, T. Foran & M. Kakönen, eds. *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance*, 2009, p.209.

was the largest dam in the Southeast Asia.[886] It was the Cold War era, in which the Stalinist grand environmental policies in the Soviet Union inspired those in Mao's China.[887] With the Soviet influence, the Viet Nam government undertook major reclamation projects and the collectivization policies continued until the 1990s.[888] After the accession of the communists to power in the mid-1970s in Laos and Cambodia, the support of the US to the grand water projects suspended.[889] Cambodia withdrew from the Mekong Committee in 1975, and the committee turned into an interim committee status. The Interim Committee scaled down the previous development plans. For instance, it revised the 250 meters high Pa Mong Dam to 210 meters.[890] This is one of the reasons why the mainstream Mekong remained relatively untouched until very recently.[891] On the other hand, the Mekong Committee

[886] François Molle, Tira Foran & Philippe Floch, "Introduction: Changing Waterscapes in the Mekong Region – Historical Background and Context," in F. Molle, T. Foran & M. Käkönen, eds. *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance*, 2009, p.6.

[887] F. Molle, P.P. Mollinga & P. Wester, "Hydraulic Bureaucracies and the Hydraulic Mission: Flows of Water, Flows of Power," *Water Alternatives*, vol. 2, no. 3, 2009, p.334.

[888] David Biggs, Fiona Miller, Chu Hoanh & François Molle, "The Delta Machine: Water Management in the Vietnamese Mekong Delta in Historical and Contemporary Perspectives," in F. Molle, T. Foran & M. Kakönen, eds. *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance*, 2009, p.207.

[889] Blake Ratner, "The Politics of Regional Governance in the Mekong River Basin," *Global Change Peace & Security*, vol. 15, no. 1, 2003, p.66.

[890] François Molle, Tira Foran & Philippe Floch, "Introduction: Changing Waterscapes in the Mekong Region – Historical Background and Context," in F. Molle, T. Foran & M. Käkönen, eds. *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance*, 2009, p.9; Qi Gao, *A Procedural Framework for Transboundary Water Management in the Mekong River Basin: Shared Mekong for a Common Future* (Leiden, Boston: Martinus Nijhoff Publishers, 2014), p.42.

[891] Alex Smajgl & John Ward, "Mekong Region Connectivity," in A. Smajgl & J. Ward, eds. The Water-Food-Energy Nexus in the Mekong Region: Assessing Development Strategies Considering Cross-Sectoral and Transboundary Impacts, 2013, p.2.

survived the wars and turbulence during the Cold War years and a total of fourteen water development projects were finalized until the 1990s.[892]

In the early 1990s, China planned a series of seven HPPs with a total installed capacity of 15,550 megawatts on the Upper Mekong basin, and by 1993, it has completed two major dams.[893] One of these dams was the Manwan Dam with a capacity of 1,250 megawatts. Resettled are some 3 thousand people. ADB supported the Dachaoshan Dam, opened in 2003 with an installed capacity of 1,350 megawatts. An estimated 5,200 people were resettled for the building of this dam.[894]

The 1997 Asian economic crisis was a turning point for the environmental and development history of Southeast Asia. The support and interest of the World Bank and the ADB diminished, while the importance and weight of China, Russia, and other global actors increased.[895]

In the mid-2000s, the Chinese plans became more ambitious as the Chinese authorities see the high hydropower potential in the Lancang River as part of a solution for the increasing power demand in the east of the country. The plans for the seven HPPs was updated to eight HPPs in a short while by the early 2000s.[896] By the end of the 2000s, there were numerous dams in various scales on the Mekong River (Figure 5.3). Three of them belonged to China, and they have been withdrawing

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892 Donald Weatherbee, "Cooperation and conflict in the Mekong River Basin," *Studies in Conflict & Terrorism*, vol. 20, no. 2, 1997, p.170.

893 Evelyn Goh, China in the Mekong River Basin: The Regional Security Implications of Resource Development on the Lancang Jiang, Nanyang Technological University, 2004, p.2.

894 Evelyn Goh, China in the Mekong River Basin: The Regional Security Implications of Resource Development on the Lancang Jiang, Nanyang Technological University, 2004, p.3.

895 Carl Middleton, Jelson Garcia & Tira Foran, "Old and new hydropower players in the Mekong region: Agendas and strategies," in F. Molle, T. Foran & M. Käkönen, eds. *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance*, 2009, p.26.

896 Blake Ratner, "The Politics of Regional Governance in the Mekong River Basin," *Global Change Peace & Security*, vol. 15, no. 1, 2003, p.63.

considerable amounts of water for irrigation.[897] In 2008, the Jinghong Dam with 1,750 megawatts installed capacity was completed, the construction of which began in 2003.[898] This HPP remains a small one on the Lancang as compared to the 4,200 megawatts-capacity Xiaowan Dam with its 292 meters height above thalweg. The project was estimated to cost about 3 billion US dollars[899] but completed at a total cost of 3.9 billion US dollars in 2010.

China has further plans on the Mekong River basin. The vast Nuozhadu Dam with an installed capacity of 5,850 megawatts and a height of more than 260 meters above the thalweg, which went fully online in 2014, was one of the largest and most expensive HPP projects in the world in the 2010s.[900] The budget of this enormous project was 9.6 billion US dollars, and it took ten years to complete. The reservoir behind this dam would be around 320 square kilometers, and an estimated 43,000 people had to be relocated during the construction.[901] The northernmost of these eight projects was Gongguoqiao Dam, which was completed in 2012. It has a total of 900 megawatts of installed capacity and 130 meters of dam height. The most

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[897] Peter Adamson, Ian Rutherfurd, Murray Peel & Iwona Conlan, "The Hydrology of the Mekong River," in I. Campbell, ed. *The Mekong*, 2009, p.54.

[898] China Daily, "New hydropower station completed in Yunnan," *Chinadaily.com.cn*, 2008, available at: http://www.chinadaily.com.cn/china/2008-06/19/content_6779088.htm (accessed 23 April 2017).

[899] Evelyn Goh, China in the Mekong River Basin: The Regional Security Implications of Resource Development on the Lancang Jiang, Nanyang Technological University, 2004, p.3.

[900] Michael Harris, "Last turbine unit in operation at China's 5,850-MW Huaneng Nuozhadu hydropower plant," *Hydroworld*, 2014, available at: http://www.hydroworld.com/articles/2014/06/last-turbine-unit-in-operation-at-chian-s-5-850-mw-huaneng-nuozhadu-hydropower-plant.html (accessed 23 April 2017).

[901] Patrick Scally, "Yunnan's largest hydroelectric dam goes online," *GoKunming*, 2012, available at: http://www.gokunming.com/en/blog/item/2788/yunnans_largest_hydroelectric_dam_goes_online (accessed 23 April 2017).

important impact of this dam will be sedimentation and erosion, according to international organizations.[902]

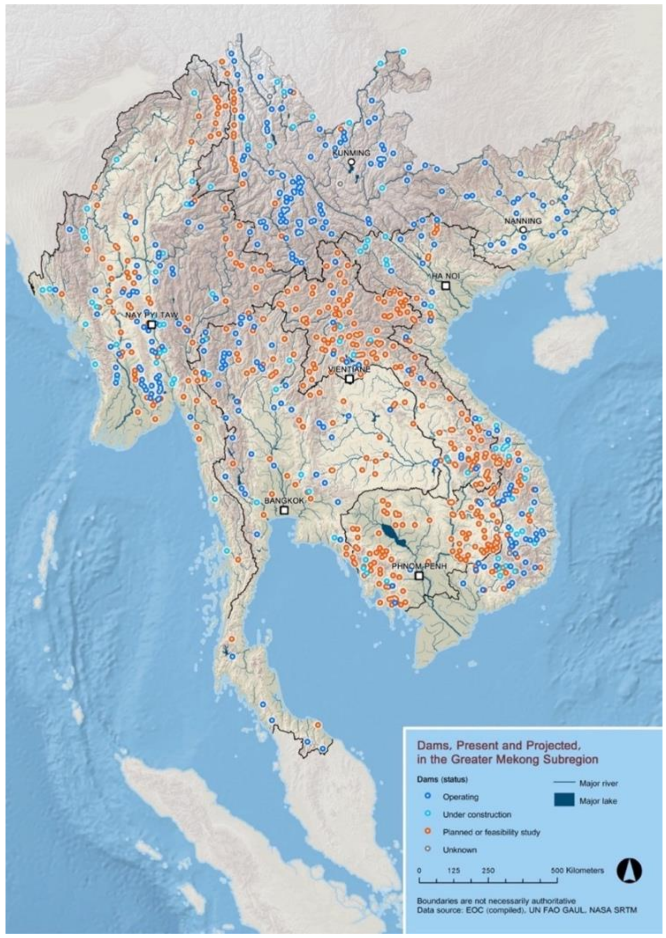

Figure 5.3. Dams in the Greater Mekong Subregion[903]

[902] International Rivers, "Comments to the Korean Foundation for Quality Regarding the Yunnan Gongguoqiao Hydropower Project (China)," *International Rivers*, 2011, available at: https://www.internationalrivers.org/resources/comments-to-the-korean-foundation-for-quality-regarding-the-yunnan-gongguoqiao-hydropower (accessed 15 July 2017).

[903] GMS, "GMS Dams," *GMS Information Portal*, 2017, available at: http://portal.gms-eoc.org/uploads/map/archives/map/GMS-Dams_17_hi-res_9.jpg (accessed 30 April 2017).

The increasing number of water development projects in the transboundary river basins in the south of China led some scholars conclude that the tendency of water-related conflict is escalating in the Southeast and South Asia. Gleick claims that these may turn into violent conflicts unless comprehensive reconciliation could be reached on the hydropower development on the Mekong River.[904] In a similar vein, Pearse-Smith argued that the water-related problems between the riparian states seem to escalate due to ambitious and rapidly growing hydroelectricity projects on the Mekong River.[905]

Hydroelectricity production has been an important factor in Southeast Asia, especially in the Mekong,[906] the Salween, the Indus, the Ganges-Brahmaputra-Meghna, and other upstream rivers in Chinese Tibet.[907] According to some authors, the likelihood of violent conflict is lower due to the presence of regional institutions and economic interdependence.[908] This high level of economic interdependence decreases the level of hydropolitical conflict between the upstream and the downstream riparians. Hydropower production and interstate electricity trade is a priority item on the agenda of the regional states.[909]

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[904] Peter Gleick, "The coming crisis over the Mekong — unconstrained development, natural droughts, and climate change," *SFGate*, 2010, available at: http://blog.sfgate.com/gleick/2010/04/03/the-coming-crisis-over-the-mekong-unconstrained-development-natural-droughts-and-climate-change/ (accessed 24 April 2017).

[905] Scott Pearse-Smith, "'Water War' in the Mekong Basin?," *Asia Pacific Viewpoint*, vol. 53, no. 2, 2012, p.152.

[906] Pichamon Yeophantong, "River Activism, Policy Entrepreneurship and Transboundary Water Disputes in Asia," *Water International*, vol. 42, no. 2, 2017, p.170.

[907] Mirja Kattelus, et al., "China's Southbound Transboundary River Basins: A Case of Asymmetry," *Water International*, vol. 40, no. 1, 2015, pp.118-19.

[908] Scott Pearse-Smith, "'Water War' in the Mekong Basin?," *Asia Pacific Viewpoint*, vol. 53, no. 2, 2012, p.157.

[909] Claudia Kuenzer, et al., "Understanding the Impact of Hydropower Developments in the Context of Upstream–Downstream Relations in the Mekong River Basin," *Sustainability Science*, vol. 8, no. 4, 2013, p.582.

5.3.2. Chinese projects and the Southeast Asian riparians

The Mekong River basin is the foremost and highly politicized region in Southeast Asia. The basin populations face the risk of poverty and political conflict,[910] along with the problems with fisheries, relocation because of large dams,[911] water pollution, flooding, and issues of navigation.[912] As summarized in the previous section in this chapter, the Chinese government initially planned eight big dams on the Mekong mainstream, most of which have been completed as of 2017.[913] The government of China plans to add more than 20 dams to the completed seven.[914] One of the major aims of the Chinese government in developing the mainstream Mekong is to meet the water and electricity demand of the people in Yunnan and nearby provinces, and export the excess electricity. Also, decreasing the number of immigrants towards the coastal regions in the western part of the country and regulating water flow are the main purposes of the dams on the Mekong.[915] According to the Chinese officials, the dams would benefit all living downstream as the dams would

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[910] Ian Campbell, "The Challenges for Mekong River Management," in I. Campbell, ed. *The Mekong: Biophysical Environment of an International River Basin* 1st ed., 2009, pp.404-06.

[911] P. Wang, J. Lassoie, S. Dong & S. Morreale, "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*, vol. 117, 2013.

[912] Ian Campbell, "The Challenges for Mekong River Management," in I. Campbell, ed. *The Mekong: Biophysical Environment of an International River Basin* 1st ed., 2009, pp.406-10.

[913] See: Timo Räsänen, et al., "Observed river discharge changes due to hydropower operations in the Upper Mekong Basin," *Journal of Hydrology*, vol. 545, 2017; Richard Bernstein, "China's Mekong Plans Threaten Disaster for Countries Downstream," *Foreign Policy*, 2017, available at: http://foreignpolicy.com/2017/09/27/chinas-mekong-plans-threaten-disaster-for-countries-downstream/ (accessed 8 January 2018).

[914] Ame Trandem, "Is the Mekong at a Tipping Point?," *World Rivers Review*, vol. 29, no. 4, 2014, p.15; R.Edward Grumbine & Jianchu Xu, "Mekong Hydropower Development," *Science*, vol. 332, no. 6026, 2011, p.178.

[915] Sokhem Pech, "Water Sector Analysis," in A. Smajgl & J. Ward, eds. The Water-Food-Energy Nexus in the Mekong Region: Assessing Development Strategies Considering Cross-Sectoral and Transboundary Impacts, 2013, p.29.

provide “increased irrigation, flood control, navigation, and dry-season power generation.”[916] They also claim that the dams will benefit the environment as they would reduce Chinese dependence on coal for electricity production, and reduce the impacts of floods downstream.[917]

There are some contrary arguments as well. As Pech illustrates, the Upper and Lower Mekong mainstream dams only partially contribute to the flood protection efforts of the downstream countries.[918] Similarly, international organizations and academicians observe that the water development projects of China in the Upper Mekong River basin have been a primary source of problems in the region, especially the problems related to ecology and socioeconomic situation.[919] Goh gives some particular examples: shortage of water during the filling of the great dams,[920] such as the Xiaowan and Nuozhadu; the impact of flow regulation on the natural cycle of floods, which are crucial for the traditional agriculture and ecosystem

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916 Blake Ratner, "The Politics of Regional Governance in the Mekong River Basin," *Global Change Peace & Security*, vol. 15, no. 1, 2003, p.63.

917 The Guardian, "Dam the consequences," *The Guardian*, 2007, available at: https://www.theguardian.com/world/2007/apr/06/outlook.development (accessed 24 April 2017); Stuart Orr, Jamie Pittock, Ashok Chapagain & David Dumaresq, "Dams on the Mekong River: Lost Fish Protein and the Implications for Land and Water Resources," *Global Environmental Change*, vol. 22, no. 4, 2012.

918 Sokhem Pech, "Water Sector Analysis," in A. Smajgl & J. Ward, eds. The Water-Food-Energy Nexus in the Mekong Region: Assessing Development Strategies Considering Cross-Sectoral and Transboundary Impacts, 2013, p.34.

919 Scott Pearse-Smith, "‘Water War’ in the Mekong Basin?," *Asia Pacific Viewpoint*, vol. 53, no. 2, 2012, p.152. See also: The Guardian, "Dam the consequences," *The Guardian*, 2007, available at: https://www.theguardian.com/world/2007/apr/06/outlook.development (accessed 24 April 2017); Stuart Orr, Jamie Pittock, Ashok Chapagain & David Dumaresq, "Dams on the Mekong River: Lost Fish Protein and the Implications for Land and Water Resources," *Global Environmental Change*, vol. 22, no. 4, 2012; Timo Räsänen, et al., "Observed river discharge changes due to hydropower operations in the Upper Mekong Basin," *Journal of Hydrology*, vol. 545, 2017.

920 This concern of Goh turned into reality after the completion of some of the dams in the Upper Mekong cascade. See: Calum MacLeod, "China's new dam seen as a water hog," *USA Today*, 2010, available at: http://usatoday30.usatoday.com/news/world/environment/2010-04-21-china-dam_N.htm (accessed 23 April 2017).

sustainability and the need for using artificial fertilizers as a consequence; ecosystem degradation and its impact on fisheries;[921] and the problem of sedimentation causing loss of nutrients in the deltaic agricultural regions.[922] Loss of significant amounts of sedimentation increases the risk of coastal erosion in the Mekong delta and the risk of a rise in salinity.[923] The MRC estimates that the source of about half of the sedimentation is China. On the other hand, the reduced amount of sediments is beneficial for the HPP projects in the downstream countries.[924] Xi et al. found that low water levels and discharge are impacts caused by the Chinese Manwan Dam on the Mekong River.[925] Kuenzer et al. show that the dams on the mainstream Mekong will change the "flood pulse" of the river and some fragile

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[921] Environmentalist groups in Thailand argue that fisheries were affected by a drought in recent years, and the main reason for this was the dams built by China. However, the Chinese authorities, as well as the managers of the MRC, argue that the Chinese dams should not necessarily be related to the droughts. See: Calum MacLeod, "China's new dam seen as a water hog," *USA Today*, 2010, available at: http://usatoday30.usatoday.com/news/world/environment/2010-04-21-china-dam_N.htm (accessed 23 April 2017).

[922] Evelyn Goh, *China in the Mekong River Basin: The Regional Security Implications of Resource Development on the Lancang Jiang*, Nanyang Technological University, 2004, pp.4-6; Sokhem Pech, "Water Sector Analysis," in A. Smajgl & J. Ward, eds. *The Water-Food-Energy Nexus in the Mekong Region: Assessing Development Strategies Considering Cross-Sectoral and Transboundary Impacts*, 2013, p.35.

[923] Claudia Kuenzer, et al., "Understanding the Impact of Hydropower Developments in the Context of Upstream–Downstream Relations in the Mekong River Basin," *Sustainability Science*, vol. 8, no. 4, 2013, p.581; Blake Ratner, "The Politics of Regional Governance in the Mekong River Basin," *Global Change Peace & Security*, vol. 15, no. 1, 2003, p.64.

[924] Claudia Kuenzer, et al., "Understanding the Impact of Hydropower Developments in the Context of Upstream–Downstream Relations in the Mekong River Basin," *Sustainability Science*, vol. 8, no. 4, 2013, p.576.

[925] Lu Xi, Wang Jian-Jun & Carl Grundy-Warr, "Are the Chinese Dams to be Blamed for the Lower Water Levels in the Lower Mekong?," in M. Kummu, M. Keskinen & O. Varis, eds. *Modern Myths of the Mekong: A Critical Review of Water and Development Concepts, Principles and Policies*, 2008, pp.45-48. See, for a discussion on the social impacts of the Manwan Dam: Bryan Tilt, Yvonne Braun & Daming He, "Social impacts of large dam projects: A comparison of international case studies and implications for best practice," *Journal of Environmental Management*, vol. 90, 2009, pp.S254-55.

dependent ecosystems, such as the Tonlé Sap.[926] This will, in turn, affect the socioeconomic standards of the people in an indirect manner.[927] Lamberts, on the other hand, argues that "[i]t is too early and there are insufficient data to draw conclusions about whether flow variations that are being observed are indeed manmade or natural variations."[928]

The regional governments have concerns on Chinese plans on the Mekong River. The Laotian and Cambodian officials complain about the unilateral actions of the Chinese government.[929] The downstream riparians often blame the upstream dam projects for the environmental degradation by which they were affected considerably. Also, there are numerous projects of dams and other hydraulic works on the tributaries and the mainstream of the Mekong River. The completion of these projects will have significant impacts on water level, flow level, flood timing and duration, flooded area, reverse flow timing in Tonlé Sap, water quality, salinity, sedimentation, ecosystem, delta formation, and other similar crucial issues.[930] In recent years, regional civil society and environmental group endeavors tend to be

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[926] Sokhem Pech, "Water Sector Analysis," in A. Smajgl & J. Ward, eds. The Water-Food-Energy Nexus in the Mekong Region: Assessing Development Strategies Considering Cross-Sectoral and Transboundary Impacts, 2013, p.35.

[927] Claudia Kuenzer, et al., "Understanding the Impact of Hydropower Developments in the Context of Upstream–Downstream Relations in the Mekong River Basin," *Sustainability Science*, vol. 8, no. 4, 2013, pp.574-75.

[928] Dirk Lamberts, "Little Impact, Much Damage: The Consequences of Mekong River Flow Alterations for the Tonle Sap Ecosystem," in M. Kummu, M. Keskinen & O. Varis, eds. *Modern Myths of the Mekong: A Critical Review of Water and Development Concepts, Principles and Policies*, 2008, p.8.

[929] Blake Ratner, "The Politics of Regional Governance in the Mekong River Basin," *Global Change Peace & Security*, vol. 15, no. 1, 2003, p.63.

[930] Sokhem Pech, "Water Sector Analysis," in A. Smajgl & J. Ward, eds. The Water-Food-Energy Nexus in the Mekong Region: Assessing Development Strategies Considering Cross-Sectoral and Transboundary Impacts, 2013, p.37.

more decisive on the unilateral actions of regional states, especially those of Chinese government.[931] Some international organizations have a neutral stance on the projects of the Chinese government. According to the World Bank, there will be positive and negative impacts of the water development projects in the Upper Mekong on the Lower Mekong countries.[932]

It can be argued that regional hydropolitical problems may emerge in the future if China intends to use its upstream position and its control over water flow downstream for diplomatic purposes.[933] Some authors suggest an IWRM approach for addressing the transboundary water management issues, yet the history of political conflict in the history of the Mekong River basin, and in the history of Cambodia in particular, is a major setback for cooperation.[934]

The Salween River was once known as one of the world's longest undammed rivers until the mid-2010s. The governments of China and Myanmar are planning to build a series of dams on the Salween basin. The projects are, however, highly controversial among the population of the basin. This controversy has the potential of exacerbating further given the ethnic composition of the basin and the internal political dispute in Myanmar.[935] The political turmoil in Thailand has also had

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[931] Pichamon Yeophantong, "River Activism, Policy Entrepreneurship and Transboundary Water Disputes in Asia," *Water International*, vol. 42, no. 2, 2017.

[932] World Bank / Asian Development Bank, *Mekong Water Resources Assistance Strategy*, WB/ADB, 2006, p.11.

[933] Evelyn Goh, *China in the Mekong River Basin: The Regional Security Implications of Resource Development on the Lancang Jiang*, Nanyang Technological University, 2004, p.6; Richard Bernstein, "China's Mekong Plans Threaten Disaster for Countries Downstream," *Foreign Policy*, 2017, available at: http://foreignpolicy.com/2017/09/27/chinas-mekong-plans-threaten-disaster-for-countries-downstream/ (accessed 8 January 2018).

[934] Olli Varis, Matti Kummu, Marko Keskinen & Juha Sarkkula, "Integrated Water Resources Management on the Tonle Sap Lake, Cambodia," *Water Science & Technology Water Supply*, vol. 6, no. 5, 2006, p.55.

[935] Salween Watch Coalition, *Current Status of Dams on the Salween River*, 2016, available at: https://www.internationalrivers.org/resources/11286 (accessed 20 April 2017), p.2. See also: Conversation Global, "The plan to dam Asia's last free-flowing, international river," *Huffpost*,

impacts on the hydropolitics of the Salween River basin. After the coup d'etat in Thailand in 2014, the Minister of Energy of Thailand visited Myanmar and discussed possibilities of cooperation on energy issues. The highly controversial Mong Ton Dam was on the agenda too.[936] Another controversial dam project is the Hat Gyi Dam near the Thailand border. This dam is also closely related to political conflict as it will locate in the Karen state, a major area of armed conflict.[937] Further projects are subject to political conflicts a well.

Similar to the Mekong, the Irrawaddy River is another water body in Southeast Asia shared by Myanmar and China. Although only about 10 percent of the Irrawaddy River basin is in China, the river has been a symbol of bilateral relations between the riparians. Especially the Myitsone Dam project, which was suspended in 2011 by the Myanmar government as a sign of resistance against the Chinese dominance in the region, has a particular political meaning.[938] The bilateral hydropolitical relations between Myanmar and China are mostly related to hydropower and electricity trade.

Similarly, Chinese dam and water diversion projects, especially those on the Brahmaputra River basin, which are on the agenda of China-India bilateral relations

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2017, available at: https://www.huffingtonpost.com/the-conversation-global/the-plan-to-dam-asias-las_b_13937292.html (accessed 3 January 2018); ICEM, *Developing a Strategic Environmental Assessment (SEA) of the Hydropower Sector in Myanmar*, International Finance Corporation (IFC), 2017, available at: https://www.ifc.org/wps/wcm/connect/18a7d2ba-cb5b-485f-8dcf-fb766660f019/AAS1605-REP-002-01_Regional-River-Basin-Consultation_Final-Draft-060517.pdf?MOD=AJPERES (accessed 3 January 2018).

[936] Salween Watch Coalition, *Current Status of Dams on the Salween River*, 2016, available at: https://www.internationalrivers.org/resources/11286 (accessed 20 April 2017), p.10.

[937] Salween Watch Coalition, *Current Status of Dams on the Salween River*, 2016, available at: https://www.internationalrivers.org/resources/11286 (accessed 20 April 2017), p.4.

[938] Brahma Chellaney, "China's dam problem with Burma," *Inquirer.net*, 2016, available at: http://opinion.inquirer.net/97718/chinas-dam-problem-with-burma (accessed 5 January 2018); Jeff Howe, "Myanmar: A power play on the Irrawaddy River," *PRI*, 2012, available at: https://www.pri.org/stories/2012-10-29/myanmar-power-play-irrawaddy-river; (accessed 4 January 2018); Mike Ives, "A Chinese-Backed Dam Project Leaves Myanmar in a Bind," *The New York Times*, 2017, available at: https://www.nytimes.com/2017/03/31/world/asia/myanmar-china-myitsone-dam-project.html (accessed 6 January 2018).

since the 1990s,[939] concern the Indians[940] and other downstream countries.[941] In the 2010s, the Chinese government acknowledged the disputed schemes on the upper reaches of the Brahmaputra River basin and claimed that these are run-of-the-river projects for electricity generation purposes[942] and no large reservoirs will be built for the operation of these dams. In 2011, Chinese authorities denied any claims for water diversion plans in the upper reaches of the Brahmaputra River basin.[943] Still, lack of communication and mutual trust between the Indian and the Chinese governments increase the level of concern for the downstream riparians,[944] and may cause serious political tensions.[945] On the other hand, India has some dam schemes

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[939] Water Politics, "Geopolitics Of The Brahmaputra-Ganges-Meghna River Basin," *Water Politics*, 2015, available at: http://www.waterpolitics.com/2015/01/01/geopolitics-of-the-brahmaputra-ganges-meghna-river-basin/ (accessed 14 January 2018). See also: Jonathan Holslag, "Assessing the Sino-Indian Water Dispute," *Journal of International Affairs*, vol. 64, no. 2, 2011; Claude Arpi, "Diverting the Brahmaputra: Declaration of War?," *The Rediff Special*, 2003, available at: http://www.rediff.com/news/2003/oct/27spec.htm (accessed 17 January 2018).

[940] BBC News, "Megadams: Battle on the Brahmaputra," *BBC*, 2014, available at: http://www.bbc.com/news/world-asia-india-26663820 (accessed 11 January 2018); Sana Hashmi, "China Dams the Brahmaputra: Why India Should Worry," *Rediff News*, 2015, available at: http://www.rediff.com/news/column/china-dams-the-brahmaputra-why-india-should-worry/20151021.htm (accessed 16 January 2018); The Hindu Business Line, "China for More Dams on Tibetan Rivers Instead of Brahmaputra," *The Hindu Business Line*, 2017, available at: http://www.thehindubusinessline.com/news/world/china-for-more-dams-on-tibetan-rivers-instead-of-brahmaputra/article9970509.ece (accessed 13 January 2018); Ashok Swain, "China's Water Diversion Is Not Responsible For Brahmaputra River Turning Black," *Outlook India*, 2017, available at: https://www.outlookindia.com/website/story/chinas-water-diversion-is-not-responsible-for-brahmaputra-river-turning-black/305449 (accessed 16 January 2018).

[941] Sudha Ramachandran, "Water Wars: China, India and the Great Dam Rush," *The Diplomat*, 2015, available at: https://thediplomat.com/2015/04/water-wars-china-india-and-the-great-dam-rush (accessed 4 January 2018).

[942] Sudha Ramachandran, "Water Wars: China, India and the Great Dam Rush," *The Diplomat*, 2015, available at: https://thediplomat.com/2015/04/water-wars-china-india-and-the-great-dam-rush (accessed 4 January 2018).

[943] Hongzhou Zhang, "Sino-Indian Water Disputes: The Coming Water Wars," *WIREs Water*, vol. 3, 2016, p.158.

[944] Jonathan Holslag, "Assessing the Sino-Indian Water Dispute," *Journal of International Affairs*, vol. 64, no. 2, 2011, pp.23-24.

[945] Hongzhou Zhang, "Sino-Indian Water Disputes: The Coming Water Wars," *WIREs Water*, vol. 3, 2016.

on the Brahmaputra River basin as well. Prominent among them are the hydropower sheme in the Lower Subansiri and the Dibang hydropower project in the south of the Arunachal Pradesh state of India.[946] The dependence of India on the freshwater resources originating from China is critical in this respect. The level of this dependence is 30 percent, according to estimates.[947] Also, severe floods in India and trapping of sediments in the planned reservoirs in China is a source of major concern for the downstream countries.[948] These will be further discussed in the following section.

5.3.3. Agriculture and irrigation

Agriculture in the northeastern part of China is an important economic activity. In the Amur River basin, China is the leading agricultural producer with 26.3 million hectares of cropland in the river basin by the early 2000s.[949] The main agricultural product in Jilin is corn and the corn exports from Jilin province corresponds to nearly two-thirds of total corn exports of China. Grain is cultivated on about 70 percent of the total cropland in Jilin province.[950] In general, corn, rice, soybean, and

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[946] Mirza Rahman, "China and India's Race to Dam the Brahmaputra River puts the Himalayas at Risk," *The Conversation*, 2016, available at: https://theconversation.com/china-and-indias-race-to-dam-the-brahmaputra-river-puts-the-himalayas-at-risk-65496 (accessed 6 January 2018). See: Power Technology, "Lower Subansiri Hydroelectric Power Project," *Power Technology*, 2017, available at: http://www.power-technology.com/projects/lower-subansiri-hydroelectric-power-project/ (accessed 16 January 2018); The Economic Times, "NHPC Gets Environmental Clearance for Rs 25,000 Crore Dibang Project," *The Economic Times*, 2015, available at: https://economictimes.indiatimes.com/industry/energy/power/nhpc-gets-environmental-clearance-for-rs-25000-crore-dibang-project/articleshow/47357642.cms?intenttarget=no (accessed 16 January 2018).

[947] Hongzhou Zhang, "Sino-Indian Water Disputes: The Coming Water Wars," *WIREs Water*, vol. 3, 2016, p.156.

[948] Jonathan Holslag, "Assessing the Sino-Indian Water Dispute," *Journal of International Affairs*, vol. 64, no. 2, 2011, pp.21-22.

[949] Amur-Heilong.net, "General Land-Use Trends in Amur-Heilong River Basin," 2017, available at: http://amur-heilong.net/http/07_landuse__chap.html (accessed 3 January 2018).

[950] Kehinde Adekola & Taiwo Akinyemi, "Agricultural Production and Development in Northeast Jilin Province of China," *International Journal of Advances in Agricultural Science and Technology*, vol. 2, no. 9, 2014, pp.2-3.

wheat are produced in the northeastern part of China. While the main agricultural activity in China takes place in the eastern part of the country,[951] the Chinese government has been supporting agricultural development and irrigation investments in this region since the early 2000s.[952]

Agriculture is especially important in the transboundary river basins in Southeast Asia. By the year 2012, some 80 percent of 60 million inhabitants in the Lower Mekong basin depend on the river for nourishment, freshwater use, and other economic activity.[953] The populations of Laos and Cambodia depend on the river for their economic survival. People of Viet Nam is also partly dependent on the river resources, while the dependency of Thailand is relatively lower.[954] One of the most important aspects of economic activity in the Mekong basin is fish production. A number of scholars argue that the dams upstream on the Mekong River are reducing the production of fish and lead to disappearance of some species.[955] Orr et al. cite that the decrease in output ranges between 30 and 90 percent in the Pak Mun, the

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[951] Jiyuan Liu, et al., "Spatial and Temporal Patterns of China's Cropland during 1990–2000: An Analysis Based on Landsat TM Data," *Remote Sensing of Environment*, vol. 98, no. 4, 2005.

[952] Amur-Heilong.net, "Agriculture in China," 2017, available at: http://amur-heilong.net/http/07_landuse_argiculture/0707agriculture_chinastory.html (accessed 6 January 2018).

[953] Stuart Orr, Jamie Pittock, Ashok Chapagain & David Dumaresq, "Dams on the Mekong River: Lost Fish Protein and the Implications for Land and Water Resources," *Global Environmental Change*, vol. 22, no. 4, 2012, p.925.

[954] Scott Pearse-Smith, "'Water War' in the Mekong Basin?," *Asia Pacific Viewpoint*, vol. 53, no. 2, 2012, p.149.

[955] R.Edward Grumbine & Jianchu Xu, "Mekong Hydropower Development," *Science*, vol. 332, no. 6026, 2011, p.178; Sokhem Pech, "Water Sector Analysis," in A. Smajgl & J. Ward, eds. *The Water-Food-Energy Nexus in the Mekong Region: Assessing Development Strategies Considering Cross-Sectoral and Transboundary Impacts*, 2013, p.35; Ame Trandem, "Is the Mekong at a Tipping Point?," *World Rivers Review*, vol. 29, no. 4, 2014; International Centre for Environmental Management, *Strategic Environmental Assessment of Hydropower on the Mekong Mainstream: Summary of the Final Report*, MRC, 2010.

Sesan, the Nam Theun, and the Hinboun tributaries. The completion of the proposed dams would further reduce the amount of fish caught,[956] forcing the river basin population find alternative ways for their diets instead of fish. This would result to a shift to agricultural production, which, in turn, would lead to an increase in irrigated agriculture in the river basin, leading to the higher withdrawal of blue water, increasing the water stress.[957] The dams in the Lower Mekong basin planned to be constructed by Laos government would reduce fisheries and impact the ecosystem. According to Grumbine and Xu, the total economic loss would amount to 500 million US dollars per year, caused by a degradation of fisheries, nutrient loss, and inundation of river banks.[958] Perch estimates that by 2030, the amount of fish caught would be reduced by 10-27 percent under the assumption that no mainstream dam on the Mekong River is built. If all the 12 proposed dams will be finished, an additional 17 percent loss would be observed.[959]

An important spot for agriculture and fishing is the Siphandone Wetlands and the fertile river banks and islands established by the branches of the Mekong River. This landscape, once dominated by the forests, were opened for agriculture, for growing rice. The river banks and islands are inhabited by about 100 thousand people in two districts in nearly 200 villages, in Khong and Mounlapamok districts,

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[956] Sokhem Pech, "Water Sector Analysis," in A. Smajgl & J. Ward, eds. The Water-Food-Energy Nexus in the Mekong Region: Assessing Development Strategies Considering Cross-Sectoral and Transboundary Impacts, 2013, p.35.

[957] Stuart Orr, Jamie Pittock, Ashok Chapagain & David Dumaresq, "Dams on the Mekong River: Lost Fish Protein and the Implications for Land and Water Resources," *Global Environmental Change*, vol. 22, no. 4, 2012, p.925.

[958] R.Edward Grumbine & Jianchu Xu, "Mekong Hydropower Development," *Science*, vol. 332, no. 6026, 2011, p.178.

[959] Sokhem Pech, "Water Sector Analysis," in A. Smajgl & J. Ward, eds. The Water-Food-Energy Nexus in the Mekong Region: Assessing Development Strategies Considering Cross-Sectoral and Transboundary Impacts, 2013, p.35.

according to a census in 1995.[960] The people here possess valuable knowledge on the fisheries in the region, on which they have depended for subsistence.[961] As the local people depend on agriculture and fisheries, the degradation in water quality and quantity inevitably affects the people.[962] In addition, the Tonlé Sap ecosystem also depends on the flood pulse. The migration of various species of fishes depend on the direction and timing of the flow and floods.[963]

In the Irrawaddy River basin, the Mu River basin is an important center for irrigated agriculture. The reservoir behind the Thapenzeik Dam is the largest water reservoir in Myanmar and is used for supporting agriculture in the Mu Valley Irrigation Project.[964]

Thailand and Laos have become major players in the hydraulic works in the Mekong River basin. Among the basin countries, Thailand has the largest arid zones in its northeast that need irrigation water. A number of water diversion projects

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[960] Giuseppe Daconto, "Siphandone Wetlands: An Overview," in G. Daconto, ed. *Siphandone Wetlands*, 2001, p.18.

[961] Ian Baird, "Local Ecological Knowledge and Small-Scale Freshwater Fisheries Management in the Mekong River in Southern Laos," in N. Haggan, B. Neis & I.G. Baird, eds. *Fishers' Knowledge in Fisheries Science and Management*, 2007; David Biggs, Fiona Miller, Chu Hoanh & François Molle, "The Delta Machine: Water Management in the Vietnamese Mekong Delta in Historical and Contemporary Perspectives," in F. Molle, T. Foran & M. Kakönen, eds. *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance*, 2009, pp.212-13.

[962] Giuseppe Daconto, "Introduction: The Siphandone Wetlands," in G. Daconto, ed. *Siphandone Wetlands*, 2001, p.2.

[963] Dirk Lamberts, "Little Impact, Much Damage: The Consequences of Mekong River Flow Alterations for the Tonle Sap Ecosystem," in M. Kummu, M. Keskinen & O. Varis, eds. *Modern Myths of the Mekong: A Critical Review of Water and Development Concepts, Principles and Policies*, 2008, pp.9-11.

[964] IFC, MOEE and MONREC, *Strategic Environmental Assessment (SEA) of the Hydropower Sector: Baseline Assessment Reports*, 2017, available at: http://www.ifc.org/wps/wcm/connect/3f136d35-74fe-4601-90f8-4a03c4d22a2b/Chapter+2_Hydro+-+Baseline+Assessment+report+-+06+Oct.pdf?MOD=AJPERES (accessed 6 January 2018), pp.48-49.

have been proposed by the Thai government in this respect.[965] Further, some projects were developed during the 2000s[966] with the assistance of the World Bank and the ADB.[967] This also reflected a significant area of cooperation of the World Bank and the ADB with the MRC.[968]

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[965] Sokhem Pech, "Water Sector Analysis," in A. Smajgl & J. Ward, eds. The Water-Food-Energy Nexus in the Mekong Region: Assessing Development Strategies Considering Cross-Sectoral and Transboundary Impacts, 2013, p.36; Tira Foran, "Impacts of Natural Resource-Led Development on the Mekong Energy System," in A. Smajgl & J. Ward, eds. The Water-Food-Energy Nexus in the Mekong Region: Assessing Development Strategies Considering Cross-Sectoral and Transboundary Impacts, 2013, p.120.

[966] Some examples are: The Kong-Loei-Chi-Mun project in Thailand, which was an updated version of the earlier Kong-Chi-Mun Project, and the Kong-Ing-Nan scheme, which aims at diverting the Mekong water form its two tributaries, the Kok and the Ing, to another basin, to the Nan river, a tributary of the Chao Phraya river. For the former, see: Ngo Vinh, "KLCM: Sucking Blood from Earth – Thailand Diverts the Mekong River and Threatens Its Water Security," *Mekong Eye*, 2016, available at: https://www.mekongeye.com/2016/11/15/klcm-sucking-blood-from-earth-thailand-diverts-the-mekong-river-and-threatens-its-water-security/ (accessed 18 June 2017). See also: Thu Suong, "Mekong basin stirs up region: Thai water diversion project could have mega risks," *Mekong Eye*, 2016, available at: https://www.mekongeye.com/2016/07/08/mekong-basin-stirs-up-region-thai-water-diversion-project-could-have-mega-risks/ (accessed 18 June 2017); Tira Foran, *Rivers of Contention: Pak Mun Dam, Electricity Planning, and State–Society Relations in Thailand, 1932–2004*, University of Sydney, 2006; Tira Foran & Kanokwan Manorom, "Pak Mun Dam: Perpetually Contested," in F. Molle, T. Foran & M. Käkönen, eds. *Contested Waterscapes in the Mekong region: hydropower, livelihoods and governance*, 2009; VietNamNet, "“Kong – Loei – Chi – Mun” Mega Project and Experts Concerns," *Mekong Eye*, 2016, available at: https://www.mekongeye.com/2016/08/17/kong-loei-chi-mun-mega-project-and-experts-concerns/ (accessed 18 June 2017). For the latter, see: Blake Ratner, "The Politics of Regional Governance in the Mekong River Basin," *Global Change Peace & Security*, vol. 15, no. 1, 2003, p.64; Ngo Vinh, "KLCM: Sucking Blood from Earth – Thailand Diverts the Mekong River and Threatens Its Water Security," *Mekong Eye*, 2016, available at: https://www.mekongeye.com/2016/11/15/klcm-sucking-blood-from-earth-thailand-diverts-the-mekong-river-and-threatens-its-water-security/ (accessed 18 June 2017); Ngo Vinh, "KLCM: Sucking Blood from Earth – Thailand Diverts the Mekong River and Threatens Its Water Security," *Mekong Eye*, 2016, available at: https://www.mekongeye.com/2016/11/15/klcm-sucking-blood-from-earth-thailand-diverts-the-mekong-river-and-threatens-its-water-security/ (accessed 18 June 2017).

[967] World Bank / Asian Development Bank, *Mekong Water Resources Assistance Strategy*, WB/ADB, 2006, p.49; Sokhem Pech, "Water Sector Analysis," in A. Smajgl & J. Ward, eds. *The Water-Food-Energy Nexus in the Mekong Region: Assessing Development Strategies Considering Cross-Sectoral and Transboundary Impacts*, 2013, p.36.

[968] Carl Middleton & Garry Lee, "New World Bank/ ADB Strategy Threatens Mekong with Controversial Infrastructure," *International Rivers*, 2007, available at: https://www.internationalrivers.org/resources/new-world-bank-adb-strategy-threatens-mekong-with-controversial-infrastructure-1920 (accessed 11 July 2017).

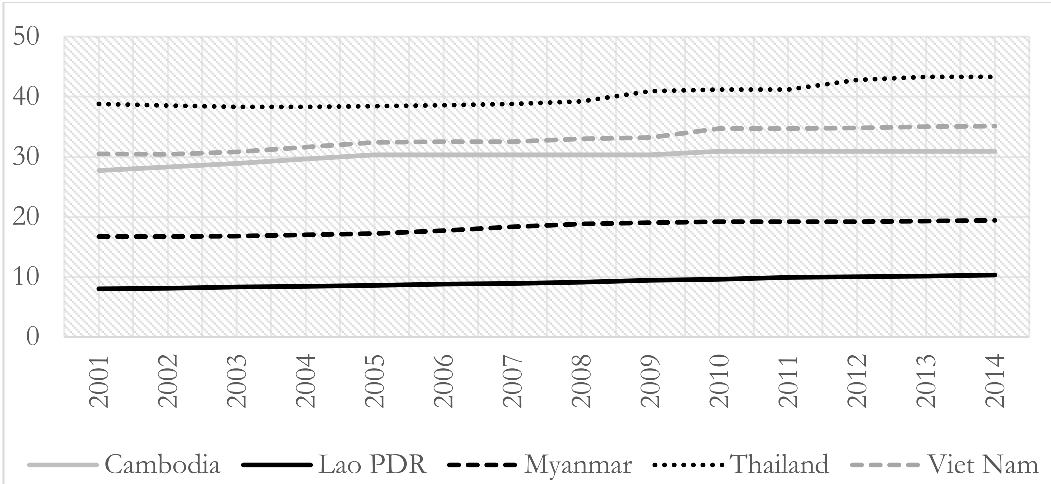

Figure 5.4. Percentage of agricultural land in the Mekong River basin countries[969]

The Mekong delta is crucial for paddy fields and fisheries in Viet Nam. Half of the rice and fish of the country is produced in the delta region. The increase of soil salinity is a major impediment to the agriculture of Viet Nam.[970] Another important spot of rice harvest is Thailand. The northern part of the country is a significant rice producer, and irrigation water is crucial for the farmers in the north Thailand.[971] The northeastern Thailand is an important agricultural zone too, being, at the same time, the region's driest part.[972] The largest water users in the Mekong River basin

[969] GMS, "Percentage of agricultural land," *GMS Information Portal*, 2017, available at: http://portal.gms-eoc.org/charts/overview/percentage-of-agricultural-land (accessed 30 April 2017).

[970] Blake Ratner, "The Politics of Regional Governance in the Mekong River Basin," *Global Change Peace & Security*, vol. 15, no. 1, 2003, p.64.

[971] Ngo Vinh, "KLCM: Sucking Blood from Earth – Thailand Diverts the Mekong River and Threatens Its Water Security," *Mekong Eye*, 2016, available at: https://www.mekongeye.com/2016/11/15/klcm-sucking-blood-from-earth-thailand-diverts-the-mekong-river-and-threatens-its-water-security/ (accessed 18 June 2017).

[972] Joakim Ojendal & Kurt Jensen, "Politics and Development of the Mekong River Basin: Transboundary Dilemmas and Participatory Ambitions," in J. Öjendal, S. Hansson & S. Hellberg, eds. *Politics and Development in a Transboundary Watershed: The Case of the Lower Mekong Basin*, 2012, p.39.

are, on the other hand, Thailand and Viet Nam. The total annual freshwater withdrawal of Thailand corresponds to nearly one third of the total available water in the basin. In general, agriculture is the biggest user of water, and about half of the water use takes place in the Mekong River delta. The agricultural water use is expected to increase in the following decades, according to estimates.[973]

The growth of economies of the Mekong River basin, especially those of China, has had a considerable impact on the basin management.[974] In the Mekong River basin, navigation,[975] agriculture and fishing are of utmost importance,[976] yet, as the fisheries of the Mekong is under severe threat,[977] the reduction in the fish production would affect other industries, such as boat construction, as well as salt, ice, fish processing industries. The losses will reach to about 2 to 4 billion US dollars by 2030, if the mainstream dam projects would be realized.[978]

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[973] Sokhem Pech, "Water Sector Analysis," in A. Smajgl & J. Ward, eds. The Water-Food-Energy Nexus in the Mekong Region: Assessing Development Strategies Considering Cross-Sectoral and Transboundary Impacts, 2013, pp.29-30.

[974] Evelyn Goh, China in the Mekong River Basin: The Regional Security Implications of Resource Development on the Lancang Jiang, Nanyang Technological University, 2004, p.7.

[975] Peter Starr, The People's Highway: Past, Present and Future Transport on the Mekong River System, Mekong River Commission, 2003.

[976] Olli Varis, Matti Kummu, Marko Keskinen & Juha Sarkkula, "Integrated Water Resources Management on the Tonle Sap Lake, Cambodia," *Water Science & Technology Water Supply*, vol. 6, no. 5, 2006, p.52.

[977] Ian Campbell, "The Challenges for Mekong River Management," in I. Campbell, ed. *The Mekong: Biophysical Environment of an International River Basin* 1st ed., 2009, pp.406-07.

[978] Sokhem Pech, "Water Sector Analysis," in A. Smajgl & J. Ward, eds. The Water-Food-Energy Nexus in the Mekong Region: Assessing Development Strategies Considering Cross-Sectoral and Transboundary Impacts, 2013, pp.35-36.

Table 5-3. Water withdrawals in the Mekong River basin[979]

	Total water withdrawal (cubic kilometers)	Share of sectors in total withdrawal (%)		
		Agriculture	Industry	Domestic
Cambodia	4,091	98	1	2
China	630,289	68	26	7
Laos	2,993	90	6	4
Myanmar	33,224	98	1	1
Thailand	87,065	95	2	2
Viet Nam	71,392	68	24	8

The Ganges-Brahmaputra-Meghna River basin is an important region for agricultural activity. India and Bangladesh are the leading countries in this basin in terms of total land area equipped for irrigation. The Food and Agriculture Organization estimated that by the end of the 2000s, total irrigated area in the Ganges-Brahmaputra-Meghna River basin was 34.1 million hectares, more than four-fifth of which is in India and 14 percent in Bangladesh.[980] In India, only one-third of 29 million hectares land in the basin is irrigated by using surface water.[981] In general, about 90

[979] Sokhem Pech, "Water Sector Analysis," in A. Smajgl & J. Ward, eds. The Water-Food-Energy Nexus in the Mekong Region: Assessing Development Strategies Considering Cross-Sectoral and Transboundary Impacts, 2013, p.30. From FAO 2005 data.

[980] Food and Agriculture Organization, "Ganges-Brahmaputra-Meghna Basin," *FAO*, 2011, available at: http://www.fao.org/nr/water/aquastat/basins/gbm/index.stm (accessed 12 January 2018).

[981] Food and Agriculture Organization, "Ganges-Brahmaputra-Meghna Basin," *FAO*, 2011, available at: http://www.fao.org/nr/water/aquastat/basins/gbm/index.stm (accessed 12 January 2018).

percent of total water withdrawals in the Ganges-Brahmaputra-Meghna River basin belong to agricultural activity.[982] In the Ganges-Brahmaputra-Meghna River basin, rice and wheat are the most important agricultural products, and the high population in the region increases the demand for agricultural production. Irrigated agriculture is more developed in the Ganges part of the basin.[983] In the northeast of India, irrigated agriculture is highly dependent on the freshwater from the Brahmaputra River basin[984] and if the Chinese plans for water diversion projects are realized, the reduced water level in the Brahmaputra River would increase water salinity, which would have adverse impacts on downstream agricultural practices.[985]

China endeavors to increase its weight in the trade of electricity in the region as well. After the satisfaction of the domestic market, there will be an excess amount of hydropower produced by China if the HPP projects are successfully completed, and the potential buyers would be Viet Nam and Thailand. On the other hand, the poorer countries, especially Laos and Cambodia, aim to increase their power exports to these two demand centers as well. This would mean that the Chinese power trade policy would be affected from the economic conditions in the region, and at the same time, it would have a definite impact on the regional economic development. The following section will discuss the possible impacts of the energy trade in Southeast Asia.

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[982] Golam Rasul, "Water for Growth and Development in the Ganges, Brahmaputra, and Meghna Basins: An Economic Perspective," *Intl. J. River Basin Management*, vol. 13, no. 3, 2015, p.388.

[983] Golam Rasul, "Water for Growth and Development in the Ganges, Brahmaputra, and Meghna Basins: An Economic Perspective," *Intl. J. River Basin Management*, vol. 13, no. 3, 2015, pp.389-90.

[984] Jonathan Holslag, "Assessing the Sino-Indian Water Dispute," *Journal of International Affairs*, vol. 64, no. 2, 2011, p.23.

[985] Sudha Ramachandran, "Water Wars: China, India and the Great Dam Rush," *The Diplomat*, 2015, available at: https://thediplomat.com/2015/04/water-wars-china-india-and-the-great-dam-rush (accessed 4 January 2018).

Table 5-4. Direct investments of China in the Mekong River basin[986]

Year	Cambodia	Laos	Myanmar	Thailand	Viet Nam
2003	2.195	80	–	5.731	1.275
2004	2.952	356	409	2.343	1.685
2005	515	2.058	1.154	477	2.077
2006	981	4.804	1.264	1.584	4.352
2007	6.445	15.435	9.231	7.641	11.088
2008	20.464	8.700	23.253	4.547	11.984
2009	21.583	20.324	37.670	4.977	11.239
2010	46.651	31.355	87.561	69.987	30.513

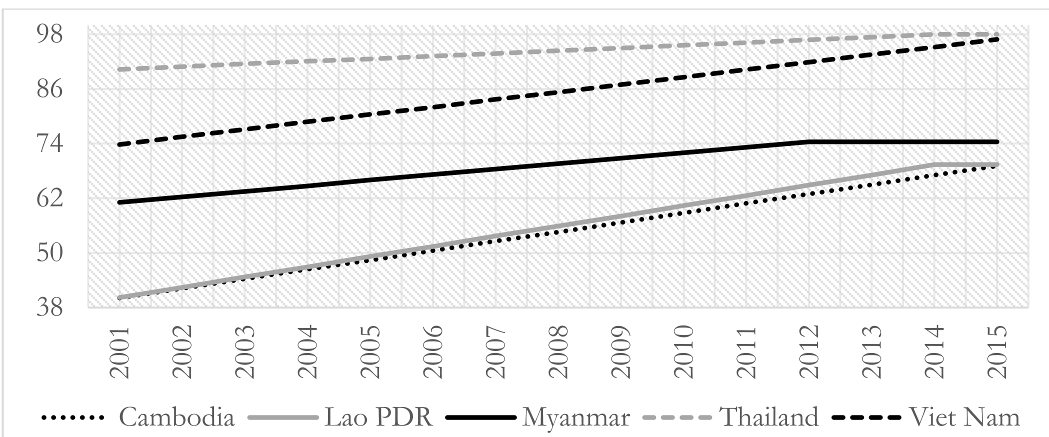

Figure 5.5. Percentage of rural population with access to improved water sources[987]

[986] Hsing-Chou Sung, "China's Geoeconomic Strategy: Toward the Riparian States of the Mekong Region," in Y. Santasombat, ed. *Impact of China's Rise on the Mekong Region*, 2015, p.37.

[987] GMS, "Percentage of rural population with access to improved water sources," *GMS Information Portal*, 2017, available at: http://portal.gms-eoc.org/charts/overview/percentage-of-rural-population-with-access-to-improved-water-sources (accessed 29 April 2017).

5.3.4. Water and economic activity in the north

The tenth longest river of the world, the Amur, or the Heilong River as it is known in China, draws the border between the Far East of Russia and Northern China. The river separates one of the most sparsely settled regions in the world from the rapidly increasing population of the world's most populous country. As of 2013, the population on the Russian side of the Amur River basin was 4.3 million, while it was 90.2 million in Chinese part in 2012.[988] Also, industrial and agricultural activity on the Chinese side of the border is denser. Agricultural lands on the Chinese part are about 20 times wider than those in Russian part of the basin. Russia generated 39 TWh of electricity in 2013, while China generated 380 TWh in 2012 alone.[989] In parallel, water consumption on the Chinese side was 67.4 cubic kilometers in 2012, while the total withdrawals of Russia were 1.32 cubic kilometers, of which only 0.19 cubic kilometers were withdrawn by the agricultural sector. More than three-fourth of Chinese withdrawals belonged to agricultural sector.[990] In the Amur River basin, the two countries have varying degrees of population, economic activity, and agriculture, and Chinese water users have almost no rivals in water use.

Since the dissolution of the Soviet Union, Russian water withdrawal has been in a steady decline, in parallel with its decreasing economic activity in the region. In 1985, Russia withdrew 2.53 cubic kilometers of water annually.[991] Chinese population and economic activity has continuously been increased since the 1950s. The

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[988] L. Gorbatenko, "Water Use in the Transboundary Basin of the Amur River," *Geography and Natural Resources*, vol. 37, no. 2, 2016, p.120.

[989] L. Gorbatenko, "Water Use in the Transboundary Basin of the Amur River," *Geography and Natural Resources*, vol. 37, no. 2, 2016, p.120.

[990] L. Gorbatenko, "Water Use in the Transboundary Basin of the Amur River," *Geography and Natural Resources*, vol. 37, no. 2, 2016, p.120. See also: Natalia Pervushina, "Water Management and Use in the Amur-Heilong River Basin: Challenges and Prospects," in V. Lagutov, ed. *Environmental Security in Watersheds: The Sea of Azov*, 2012, pp.232-33.

[991] L. Gorbatenko, "Water Use in the Transboundary Basin of the Amur River," *Geography and Natural Resources*, vol. 37, no. 2, 2016, p.116.

population of the Heilongjiang more than tripled. The population of Jilin rose from 10.1 million to 27.5 million and of the Inner Mongolia from 6.1 to nearly 25 million as of 2012. Irrigated lands of China in the basin has since increased rapidly and continuously.[992] The Amur River is a significant route for navigation, and water pollution has reached to alarming levels throughout the basin, despite decreased Russian industrial activity.[993]

Russia has some plans to develop its Far East and Baikal regions. It aims to increase investments in energy sector and has increased the level of cooperation with China since the 2000s.[994] China, on the other hand, has plans for developing manufacturing, agriculture, and energy sectors in the northeastern part of the country, in the Amur River basin.[995] Despite cooperation efforts especially in the energy sector, ambitious water development projects of China may cause disputes between the riparian countries, according to some scholars.[996]

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[992] L. Gorbatenko, "Water Use in the Transboundary Basin of the Amur River," *Geography and Natural Resources*, vol. 37, no. 2, 2016, p.118.

[993] Natalia Pervushina, "Water Management and Use in the Amur-Heilong River Basin: Challenges and Prospects," in V. Lagutov, ed. *Environmental Security in Watersheds: The Sea of Azov*, 2012, p.227

[994] Shi Ze, "Building Strong China-Russia Energy Strategic Partnership," *CIIS*, 2015, available at: http://www.ciis.org.cn/english/2015-12/02/content_8422032.htm (accessed 4 January 2018); Natalia Pervushina, "Water Management and Use in the Amur-Heilong River Basin: Challenges and Prospects," in V. Lagutov, ed. *Environmental Security in Watersheds: The Sea of Azov*, 2012, p.226. See also: Igor Dzhurko, "State program of socio-economic development of the Far East and the Baikal region as a prerequisite for Asia Pacific region global energy integration," 2013; Duncan Brown, "Energy and Trade in Russia's Far East Realignment," *The Diplomat*, 2015, available at: https://thediplomat.com/2015/12/energy-and-trade-in-russias-far-east-realignment/ (accessed 4 January 2018).

[995] Li Fangchao, "Plan to revitalize northeast region," *China Daily*, 2007, available at: http://www.chinadaily.com.cn/china/2007-08/09/content_6018172.htm (accessed 8 January 2018).

[996] Natalia Pervushina, "Water Management and Use in the Amur-Heilong River Basin: Challenges and Prospects," in V. Lagutov, ed. *Environmental Security in Watersheds: The Sea of Azov*, 2012, pp.233-34.

China shares two major river basins with North Korea, the Tumen and the Yalu River basins. The Tumen River is subject to regional development projects since the early 1990s, supported by the United Nations.[997] Although the project known as the Tumen River Development Programme or the Greater Tumen Initiative did not meet the expectations due to unwillingness of the Russian and North Korean governments based on various reasons, it is important that China continued supporting the project.[998] Currently, the Tumen River basin is under the threat of pollution, industrial and agricultural water stress.[999]

5.4. Electricity and interconnections

China is world's largest electricity consumer and producer. Unlike the US, it is a net exporter of electricity, as of 2016.[1000] Recently, the government of China has invested in the domestic electricity grid and rehabilitated the interconnections by constructing new ultra-high voltage transmission lines. As of 2013, the share of hydroelectricity in total electricity generation was 18 percent, but it is expected to increase to 22 percent by the year 2040. In Laos, Myanmar and Viet Nam, the largest share of total generating capacity belongs to hydropower.[1001] This is also valid

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[997] See: James Cotton, "China and Tumen River Cooperation: Jilin's Coastal Development Strategy," *Asian Survey*, vol. 36, no. 11, 1996; Andrew Marton, Terry McGee & Donald Paterson, "Northeast Asian Economic Cooperation and The Tumen River Area Development Project ," *Pacific Affairs*, vol. 68, no. 1, 1995; Karl Kim & Chung-Tong Wu, "Regional planning's last hurrah: The political economy of the Tumen River regional development plan," *GeoJournal*, vol. 44, no. 3, 1998.

[998] Carla Freeman, "Neighborly Relations: the Tumen development project and China's security strategy," *Journal of Contemporary China*, vol. 63, 2010, pp.138-46.

[999] UNDP/GEF, *TumenNET Strategic Action Programme*, UNDP/GEF, 2002, available at: http://iwlearn.net/resolveuid/a49a0f1fec49501de4a7e2c0f50fdee0 (accessed 5 January 2018), pp.4-7.

[1000] Enerdata, "Electricity Trade," *Global Energy Statistical Yearbook*, 2016, available at: https://yearbook.enerdata.net/electricity/electricity-balance-trade.html (accessed 12 October 2017).

[1001] The IEA excludes China from its regional analysis of the Southeast Asia. International Energy Agency, *Southeast Asia Energy Outlook*, EIA, 2015, p.39.

for the Yunnan province of China, where 62 gigawatts of installed hydropower capacity constitutes nearly three quarters of the total installed capacity.[1002]

5.4.1. Economy and electricity production

Southeast Asia is among the most densely populated regions in the world and a center for rapidly rising economies. China and India are the most populous two countries in the world. The total population of the Mekong region now exceeds 300 million,[1003] and the population of the Ganges-Brahmaputra-Meghna River basin is more than 600 million.[1004] After China and India, the largest economy is Thailand, with nearly 407 billion US dollars of gross domestic product by 2016 despite three years of consecutive contraction between 2013 and 2015.[1005] In terms of per capita gross domestic product, China is the leading economy as of 2015, and is followed by Thailand.[1006] Countries such as Myanmar, Nepal, Cambodia, Laos, Mongolia, and Bhutan have smaller economies, all having gross domestic product less than

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[1002] Darrin Magee & Thomas Hennig, "Hydropower boom in China and along Asia's rivers outpaces regional electricity demand," *thethirdpole.net*, 2017 (accessed 12 October 2017).

[1003] GMS, "Number of population," *GMS Information Portal*, 2015, available at: http://portal.gms-eoc.org/charts/all/population?gid=28&gideoc=&regoreoc=1 (accessed 19 July 2017).

[1004] Food and Agriculture Organization, "Ganges-Brahmaputra-Meghna Basin," *FAO*, 2011, available at: http://www.fao.org/nr/water/aquastat/basins/gbm/index.stm (accessed 12 January 2018).

[1005] GMS, "Gross domestic product (current prices)," *GMS Information Portal*, 2015, available at: http://portal.gms-eoc.org/charts/all/gross-domestic-product-current-prices?gid=18&gideoc=&regoreoc=1 (accessed 19 July 2017); International Monetary Fund, "World Economic Outlook Database," 2015, available at: http://www.imf.org/external/pubs/ft/weo/2015/02/weodata/index.aspx (accessed 25 November 2015).

[1006] GMS, "Gross domestic product per capita (current prices)," *GMS Information Portal*, 2015, available at: http://portal.gms-eoc.org/charts/all/gross-domestic-product-per-capita-current-prices?gid=18&gideoc=18&regoreoc=1 (accessed 19 July 2017); International Monetary Fund, "World Economic Outlook Database," 2015, available at: http://www.imf.org/external/pubs/ft/weo/2015/02/weodata/index.aspx (accessed 25 November 2015).

100 billion US dollars as of 2015.[1007] Therefore, the smaller economies of Southeast Asia seek ways of economic growth, and large scale water development projects are high on the agenda.

One of the major economic problems in the Lower Mekong River basin and in the Ganges-Brahmaputra-Meghna River basin is poverty. In Viet Nam, the level of poverty was most severe in the 1990s and 2000s, but it declined considerably by 2012. In Laos, on the other hand, poverty levels remain still high, despite slight improvements in the 2010s (Figure 5.6).[1008] This situation has made the Mekong River basin as one of the hotspots for worldwide development endeavors, and hydropower became the main tool for rapidly achieving development aims.[1009] In the Ganges-Brahmaputra-Meghna River basin, one-fifth of the population have no access to potable water.[1010] As of 2014, access to electricity in Bangladesh was 62.4 percent of total population, while the share was 75 percent in India, and 63.4 percent in Nepal.[1011] The share of renewable electricity in Bangladesh was only 1.3 percent

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[1007] International Monetary Fund, "World Economic Outlook Database," 2015, available at: http://www.imf.org/external/pubs/ft/weo/2015/02/weodata/index.aspx (accessed 25 November 2015).

[1008] R.Edward Grumbine & Jianchu Xu, "Mekong Hydropower Development," *Science*, vol. 332, no. 6026, 2011, p.178.

[1009] Stina Hansson, Sofie Hellberg & Joakim Ojendal, "Politics and Development in a Transboundary Watershed: The Case of the Lower Mekong Basin," in J. Öjendal, S. Hansson & S. Hellberg, eds. *Politics and Development in a Transboundary Watershed*, 2012, p.10; Pichamon Yeophantong, "River Activism, Policy Entrepreneurship and Transboundary Water Disputes in Asia," *Water International*, vol. 42, no. 2, 2017, p.170.

[1010] Golam Rasul, "Water for Growth and Development in the Ganges, Brahmaputra, and Meghna Basins: An Economic Perspective," *Intl. J. River Basin Management*, vol. 13, no. 3, 2015, p.387.

[1011] World Bank, "Sustainable Energy for All," *The World Bank Databank*, 2014, available at: http://databank.worldbank.org/data/reports.aspx?source=sustainable-energy-for-all (accessed 15 January 2018).

by 2014, while the share in India was 15.7, and in Nepal and Bhutan, 100 percent.[1012]

China, the most developed country in the Mekong River basin, is an important donor[1013] and investor country[1014] in the region. Between 2003 and 2010, Myanmar received about 1.6 billion US dollars' worth foreign direct investment, followed by Cambodia, Thailand, Laos and Viet Nam (Table 5-4), as officially announced by the government of China. There is an active trade relationship between the countries in the region. China occupies a major role in the trade volume of the Mekong River basin countries.[1015]

1012 World Bank, "Sustainable Energy for All," *The World Bank Databank*, 2014, available at: http://databank.worldbank.org/data/reports.aspx?source=sustainable-energy-for-all (accessed 15 January 2018).

1013 Hsing-Chou Sung, "China's Geoeconomic Strategy: Toward the Riparian States of the Mekong Region," in Y. Santasombat, ed. *Impact of China's Rise on the Mekong Region*, 2015, pp.34-35.

1014 Hsing-Chou Sung, "China's Geoeconomic Strategy: Toward the Riparian States of the Mekong Region," in Y. Santasombat, ed. *Impact of China's Rise on the Mekong Region*, 2015, p.37.

1015 Hsing-Chou Sung, "China's Geoeconomic Strategy: Toward the Riparian States of the Mekong Region," in Y. Santasombat, ed. *Impact of China's Rise on the Mekong Region*, 2015, pp.38-40.

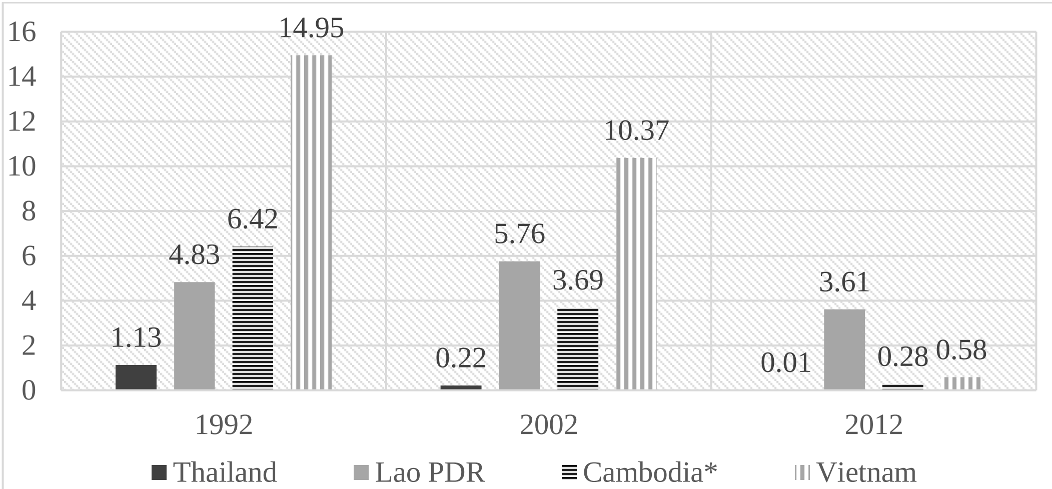

Figure 5.6. Poverty gap at 1.90 US dollars a day in Lower Mekong countries[1016]

Mainly for development purposes, Laos brought the proposal for eleven dams with a total of 15,000 megawatts of installed capacity onto the agenda of the MRC in September 2010,[1017] with the ambition of being "the battery of Asia."[1018] This capacity is estimated to correspond to 8 percent of the regional electricity demand by the year 2025, generating a revenue of 3.7 billion US dollars annually.[1019] One of the most controversial projects was the Xayaburi Dam and HPP in northern Laos. It is expected to have an installed capacity of 1,285 megawatts[1020] and cost at 3.5

[1016] Data for 2011, PPP, percentage. See: World Bank, "World Development Indicators," *The World Bank Databank*, 2017, available at: http://data.worldbank.org (accessed 31 January 2017). * Cambodia data for 1994, 2004, 2012, respectively.

[1017] R.Edward Grumbine & Jianchu Xu, "Mekong Hydropower Development," *Science*, vol. 332, no. 6026, 2011, p.178.

[1018] Stuart Orr, Jamie Pittock, Ashok Chapagain & David Dumaresq, "Dams on the Mekong River: Lost Fish Protein and the Implications for Land and Water Resources," *Global Environmental Change*, vol. 22, no. 4, 2012, p.931.

[1019] R.Edward Grumbine & Jianchu Xu, "Mekong Hydropower Development," *Science*, vol. 332, no. 6026, 2011, p.178.

[1020] Pichamon Yeophantong, "River Activism, Policy Entrepreneurship and Transboundary Water Disputes in Asia," *Water International*, vol. 42, no. 2, 2017, p.173.

billion US dollars, approximately. The financing will come from the commercial banks based in Thailand and the generated power will be transferred to the Thai market. The project became subject to criticism because of environmental concerns. The international organizations, as well as local actors, such as the Vietnamese media, criticized the scheme.[1021] The activist groups in Thailand, Cambodia and Viet Nam endeavored to influence the decision-making process with regards the dam, but they had limited impacts.[1022]

Myanmar is another rising hydropower generating country in Southeast Asia, especially in the Irrawaddy and Salween River basins. Since the first large scale HPP was opened in the 1960s, hydropower production in Myanmar has been developing. The large HPPs in the country have a total of 3,298 megawatts of capacity as of 2017.[1023] This corresponds only to a small percentage of the total hydropower potential of the country, which is estimated to be 100 thousand megawatts.[1024] The electrification in the rural areas of Myanmar is poor, with only 20 percent of the population on average has access to electricity by 2016. As the economy of the country grows and as the level of poverty decreases, the domestic electricity demand increases.[1025] On the other hand, there is an increasing demand from Chinese

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[1021] Joakim Ojendal & Kurt Jensen, "Politics and Development of the Mekong River Basin: Transboundary Dilemmas and Participatory Ambitions," in J. Öjendal, S. Hansson & S. Hellberg, eds. *Politics and Development in a Transboundary Watershed: The Case of the Lower Mekong Basin*, 2012, pp.46-47.

[1022] Pichamon Yeophantong, "River Activism, Policy Entrepreneurship and Transboundary Water Disputes in Asia," *Water International*, vol. 42, no. 2, 2017, pp.174-76.

[1023] IFC, MOEE and MONREC, *Strategic Environmental Assessment (SEA) of the Hydropower Sector: Baseline Assessment Reports*, 2017, available at: http://www.ifc.org/wps/wcm/connect/3f136d35-74fe-4601-90f8-4a03c4d22a2b/Chapter+2_Hydro+-+Baseline+Assessment+report+-+06+Oct.pdf?MOD=AJPERES (accessed 6 January 2018), p.11.

[1024] International Hydropower Association, "Myanmar," *IHA*, 2015, available at: https://www.hydropower.org/country-profiles/myanmar (accessed 14 January 2018).

[1025] IFC, MOEE and MONREC, *Strategic Environmental Assessment (SEA) of the Hydropower Sector: Baseline Assessment Reports*, 2017, available at: http://www.ifc.org/wps/wcm/connect/3f136d35-74fe-4601-90f8-

economy for electricity as well. China has had a major share in many HPP projects in the country and buys electricity directly from the HPPs it built or operate in Myanmar.[1026] The electricity trade between the riparians in the Irrawaddy and the Salween River basins will be further analyzed in the following paragraphs.

Not only the lesser developed economies, but also the great economies of Southeast Asia also plan to develop river basins. Since the beginning of the 2000s, China recognized its potential and has built a huge number of HPPs totaling over 300 gigawatts nation-wide. The Yunnan province has been promoted as a battery for the Southeast Asia. Between 2000 and 2016, the installed hydropower capacity in Yunnan reached to 62 gigawatts, an increase about 10 times the capacity in 2000.[1027] The electricity production in Yunnan was 262 TWh in 2015, while consumption remained on 167 TWh level, which means that the region is a significant electricity exporter. On the other hand, the region exports more than 98 percent to the east, to Guangdong, while only 1.4 TWh is exported to the downstream countries in the Mekong River basin.[1028]

Transferring electricity from the Yunnan province to the most populous eastern part of the country has been among the long-term aims of Chinese development strategy. Also, Chinese authorities desire to export electricity to the Southeast Asian countries. China has the largest hydropower potential in the world, estimated at 378

4a03c4d22a2b/Chapter+2_Hydro+-+Baseline+Assessment+report+-+06+Oct.pdf?MOD=AJPERES (accessed 6 January 2018), p.12.

[1026] See: International Finance Corporation; Ministry of Electricity and Energy; Myanmar Ministry of Natural Resources and Environmental Conservation, *Strategic Environmental Assessment of the Hydropower Sector in Myanmar*, IFC, 2017, available at: http://www.ifc.org/wps/wcm/connect/industry_ext_content/ifc_external_corporate_site/hydro+advisory/resources/sea+of+the+hydropower+sector+in+myanmar+resources+page (accessed 4 January 2018), p.55.

[1027] Darrin Magee & Thomas Hennig, "Hydropower boom in China and along Asia's rivers outpaces regional electricity demand," *thethirdpole.net*, 2017 (accessed 12 October 2017).

[1028] Darrin Magee & Thomas Hennig, "Hydropower boom in China and along Asia's rivers outpaces regional electricity demand," *thethirdpole.net*, 2017 (accessed 12 October 2017).

thousand megawatts. On the regional level, Yunnan has the second greatest hydro-electricity potential among Chinese provinces.[1029] China has HPP projects outside of its borders, on the mainstreams of the Ganges-Brahmaputra, the Mekong, the Irrawaddy, and the Salween rivers. If all plans of China are realized, the total installed capacity on the Irrawaddy would reach to 28.1 gigawatts from its 2.1 gigawatt level as of 2017. The total installed capacity on the Salween would reach to 16.5 gigawatts, on the other hand.[1030] Only in Myanmar's hydropower sector, China has 34 projects, the total capacity of which equals to about 35 gigawatts.[1031] The most controversial HPP project in Myanmar supported by China is the Myitsone Dam and HPP. The 140-meter dam is proposed to have an installed capacity of 6,000 megawatts with a total annual generation of about 31.2 thousand GWh. The government has suspended the project in 2011. According to the intergovernmental agreements, 90 percent of the total electricity generated in the Myitsone HPP would be exported directly to China, while 10 percent is reserved for domestic consumption in Myanmar.[1032] As of 2017, the largest HPP in Myanmar is the 132-meter Yeywa Dam, which has been online since 2010, with an installed capacity of 790

[1029] Evelyn Goh, China in the Mekong River Basin: The Regional Security Implications of Resource Development on the Lancang Jiang, Nanyang Technological University, 2004, pp.7-8.

[1030] International Finance Corporation; Ministry of Electricity and Energy; Myanmar Ministry of Natural Resources and Environmental Conservation, *Strategic Environmental Assessment of the Hydropower Sector in Myanmar*, IFC, 2017, available at: http://www.ifc.org/wps/wcm/connect/industry_ext_content/ifc_external_corporate_site/hydro+advisory/resources/sea+of+the+hydropower+sector+in+myanmar+resources+page (accessed 4 January 2018), p.21.

[1031] International Finance Corporation; Ministry of Electricity and Energy; Myanmar Ministry of Natural Resources and Environmental Conservation, *Strategic Environmental Assessment of the Hydropower Sector in Myanmar*, IFC, 2017, available at: http://www.ifc.org/wps/wcm/connect/industry_ext_content/ifc_external_corporate_site/hydro+advisory/resources/sea+of+the+hydropower+sector+in+myanmar+resources+page (accessed 4 January 2018), p.22.

[1032] International Finance Corporation; Ministry of Electricity and Energy; Myanmar Ministry of Natural Resources and Environmental Conservation, *Strategic Environmental Assessment of the Hydropower Sector in Myanmar*, IFC, 2017, available at: http://www.ifc.org/wps/wcm/connect/industry_ext_content/ifc_external_corporate_site/hydro+advisory/resources/sea+of+the+hydropower+sector+in+myanmar+resources+page (accessed 4 January 2018), p.34.

megawatts.[1033] On the other hand, China has recently reduced the number of dam projects on the Chinese part of the Salween River because of electricity demand conditions and higher than anticipated costs.[1034] In the Ganges-Brahmaputra-Meghna River basin, China focuses on the Yarlung Zangbo River, which flows through the southern part of the Tibetan Plateau within Chinese political boundaries. Between 2009 and 2015, China constructed the 510 megawatts Zangmu Dam on the Yarlung Zangbo River,[1035] the first HPP on this stream. China has further dam and HPP plans on the Yarlung Zangbo, such as the Da Gu, the Jie Xu, and the Jia Chan dams,[1036] and these may be the source of political disputes between the Indian and the Chinese governments.[1037]

The economic growth in Southeast Asia is the main driver of electricity demand in the region. In the Mekong River basin, for instance, the demand is growing in Thailand, particularly, together with Viet Nam. In view of this, the other countries in the

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[1033] International Finance Corporation; Ministry of Electricity and Energy; Myanmar Ministry of Natural Resources and Environmental Conservation, *Strategic Environmental Assessment of the Hydropower Sector in Myanmar*, IFC, 2017, available at: http://www.ifc.org/wps/wcm/connect/industry_ext_content/ifc_external_corporate_site/hydro+advisory/resources/sea+of+the+hydropower+sector+in+myanmar+resources+page (accessed 4 January 2018), p.46.

[1034] Ashok Swain, "China's Water Diversion Is Not Responsible For Brahmaputra River Turning Black," *Outlook India*, 2017, available at: https://www.outlookindia.com/website/story/chinas-water-diversion-is-not-responsible-for-brahmaputra-river-turning-black/305449 (accessed 16 January 2018).

[1035] BBC News, "Megadams: Battle on the Brahmaputra," *BBC*, 2014, available at: http://www.bbc.com/news/world-asia-india-26663820 (accessed 11 January 2018); Sudha Ramachandran, "Water Wars: China, India and the Great Dam Rush," *The Diplomat*, 2015, available at: https://thediplomat.com/2015/04/water-wars-china-india-and-the-great-dam-rush (accessed 4 January 2018).

[1036] Ashok Swain, "China's Water Diversion Is Not Responsible For Brahmaputra River Turning Black," *Outlook India*, 2017, available at: https://www.outlookindia.com/website/story/chinas-water-diversion-is-not-responsible-for-brahmaputra-river-turning-black/305449 (accessed 16 January 2018).

[1037] The Hindu Business Line, "China for More Dams on Tibetan Rivers Instead of Brahmaputra," *The Hindu Business Line*, 2017, available at: http://www.thehindubusinessline.com/news/world/china-for-more-dams-on-tibetan-rivers-instead-of-brahmaputra/article9970509.ece (accessed 13 January 2018).

region try to develop their hydroelectricity export potential.[1038] Between 1993 and 2005, the average annual growth rate of regional electricity demand was 8 percent. This was one of the highest growth rates globally. This demand is expected to continue at a growth level of 6-7 percent until 2025.[1039] Energy demand from Thailand and Viet Nam is expected to continue growing at a pace of 3 and 3.8 percent annually, in respective order.[1040] For producing electricity, countries in the Mekong region use different sources. China is notorious with its coal usage for electricity production, and this is valid for Yunnan province. Thailand predominantly uses natural gas, Viet Nam coal, natural gas and hydropower, Cambodia oil, Lao and Myanmar use hydropower.[1041] It is expected that the share of electricity production from non-carbon resources will increase in the future, and the increase will stem mainly from solar photovoltaic, biomass and wind, rather than hydropower.[1042] As for the hydropower industry, the lesser developed countries in the Lower Mekong River basin seem to economically benefit from its development. It is estimated that Laos will earn 2.6 billion and the government of Cambodia 1.2 billion US dollars per annum, if the proposed dams in the late 2000s in these countries would be completed.[1043] This is possible only under the conditions that the increase of electricity

[1038] Carl Middleton, Jelson Garcia & Tira Foran, "Old and new hydropower players in the Mekong region: Agendas and strategies," in F. Molle, T. Foran & M. Käkönen, eds. *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance*, 2009, pp.23-26.

[1039] International Centre for Environmental Management, *Strategic Environmental Assessment of Hydropower on the Mekong Mainstream: Summary of the Final Report*, MRC, 2010, pp.8-9.

[1040] Tira Foran, "Impacts of Natural Resource-Led Development on the Mekong Energy System," in A. Smajgl & J. Ward, eds. *The Water-Food-Energy Nexus in the Mekong Region: Assessing Development Strategies Considering Cross-Sectoral and Transboundary Impacts*, 2013, p.105

[1041] Sunee Moungcharoen, *Following the Money Trail of Mekong Energy Industry*, Mekong Energy and Ecology Network, 2013, p.1.

[1042] Integriertes Ressourcen Management (IRM-AG), *Economics of Energy Integration: Application of MESSAGE Model in the GMS Main Report*, 2008, p.82.

[1043] International Centre for Environmental Management, *Strategic Environmental Assessment of Hydropower on the Mekong Mainstream: Summary of the Final Report*, MRC, 2010, p.10.

demand from Thailand continues. Myanmar is also seeking to develop its hydropower capacity for possible exports to Thailand and China.[1044] Laos is in the most advantageous position in the Lower Mekong River basin as it has a great potential on the tributaries and may meet its energy demand from the HPPs that can be built solely on the tributaries of the Mekong River.[1045]

In Southeast Asia, the Ganges-Brahmaputra-Meghna River basin has great hydropower potential. Especially the boundary where the Yarlung Zangbo River loses 2,300 meters of altitude is very suitable for constructing HPPs. According to estimates, Nepal has 43,000 megawatts of hydropower capacity, while Bhutan possesses about 24,000 megawatts of capacity. The total capacity of the basin is huge: about half of the total 200,000 megawatts is estimated to be economically feasible.[1046] Arunachal Pradesh state of India, the southern neighbor of China with a disputed borderline, has great hydropower potential as well. There are hundreds of dams planned in the Brahmaputra River basin in Arunachal Pradesh, but the dam projects may affect the Indian states downstream, as well as Bangladesh.[1047] Despite concerns of downstream riparians, the Chinese authorities have long been planning large HPP projects on the Yarlung Zangbo. Some claim that the installed capacity would even exceed the Three Gorges Dam, reaching to 40,000 megawatts.[1048] The Zangmu HPP, as mentioned above, has been the first hydropower

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1044 Carl Middleton, Jelson Garcia & Tira Foran, "Old and new hydropower players in the Mekong region: Agendas and strategies," in F. Molle, T. Foran & M. Käkönen, eds. *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance*, 2009, pp.39-40.

1045 International Centre for Environmental Management, *Strategic Environmental Assessment of Hydropower on the Mekong Mainstream: Summary of the Final Report*, MRC, 2010, p.10.

1046 Golam Rasul, "Water for Growth and Development in the Ganges, Brahmaputra, and Meghna Basins: An Economic Perspective," *Intl. J. River Basin Management*, vol. 13, no. 3, 2015, p.391.

1047 Paula Hanasz, *The Politics of Water Governance in the Ganges-Brahmaputra-Meghna Basin*, Observer Research Foundation, 2015, available at: www.orfonline.org/wp-content/uploads/2015/12/ORFIssueBrief_112.pdf (accessed 16 January 2018), p.5.

1048 Claude Arpi, "Diverting the Brahmaputra: Declaration of War?," *The Rediff Special*, 2003, available at: http://www.rediff.com/news/2003/oct/27spec.htm (accessed 17 January 2018).

generator on the river on Chinese side.[1049] The Brahmaputra River establishes about 40 percent of the hydropower generation capacity of India.[1050] On the Indian side, further dams, such as the 3,000-megawatts Dibang Dam,[1051] are under construction,[1052] and the 2,000-megawatts-capacity Lower Subansiri HPP went online in 2016,[1053] another controversial large dam project for the downstream riparians.[1054]

The hydroelectricity potential of the Mekong River basin remained relatively undeveloped until the mid-2000s because of political turbulence and political problems in the region.[1055] The total potential of hydropower in the whole Mekong basin is estimated at 44 – 59 thousand megawatts.[1056] The Lower Mekong River basin

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[1049] Sudha Ramachandran, "Water Wars: China, India and the Great Dam Rush," *The Diplomat*, 2015, available at: https://thediplomat.com/2015/04/water-wars-china-india-and-the-great-dam-rush (accessed 4 January 2018).

[1050] Hongzhou Zhang, "Sino-Indian Water Disputes: The Coming Water Wars," *WIREs Water*, vol. 3, 2016, p.156.

[1051] Hongzhou Zhang, "Sino-Indian Water Disputes: The Coming Water Wars," *WIREs Water*, vol. 3, 2016, p.158.

[1052] The Economic Times, "NHPC Gets Environmental Clearance for Rs 25,000 Crore Dibang Project," *The Economic Times*, 2015, available at: https://economictimes.indiatimes.com/industry/energy/power/nhpc-gets-environmental-clearance-for-rs-25000-crore-dibang-project/articleshow/47357642.cms?intenttarget=no (accessed 16 January 2018).

[1053] Power Technology, "Lower Subansiri Hydroelectric Power Project," *Power Technology*, 2017, available at: http://www.power-technology.com/projects/lower-subansiri-hydroelectric-power-project/ (accessed 16 January 2018).

[1054] R. Dutta & S. Sarma, "Lower Subansiri Hydroelectric Power Project and Future of the Subansiri River Ecosystem," *Annals of Biological Research*, vol. 3, no. 6, 2012.

[1055] Blake Ratner, "The Politics of Regional Governance in the Mekong River Basin," *Global Change Peace & Security*, vol. 15, no. 1, 2003, p.62.

[1056] Stuart Orr, Jamie Pittock, Ashok Chapagain & David Dumaresq, "Dams on the Mekong River: Lost Fish Protein and the Implications for Land and Water Resources," *Global Environmental Change*, vol. 22, no. 4, 2012, p.925; Claudia Kuenzer, et al., "Understanding the Impact of Hydropower Developments in the Context of Upstream–Downstream Relations in the Mekong River Basin," *Sustainability Science*, vol. 8, no. 4, 2013, p.568; Blake Ratner, "The Politics of Regional Governance in the Mekong River Basin," *Global Change Peace & Security*, vol. 15, no. 1, 2003, p.61.

countries constitute about 30 thousand megawatts of this total capacity.[1057] However, developing large hydroelectricity projects has the potential of affecting the economic activities of millions of people, as mentioned in the previous section.[1058] The governments of the Mekong River basin have plans that between 2011 and 2025, a total of 12 HPPs will be built on the Lower Mekong River mainstream, in addition to the other projects of China in Yunnan province. These projects will have a total installed capacity of 13 – 15 thousand megawatts.[1059] The process of completion of these HPP projects will increase the inflow of the foreign direct investment into Cambodia and Laos economies. The total amount of the investment is estimated at 25 billion US dollars.[1060]

[1057] International Centre for Environmental Management, *Strategic Environmental Assessment of Hydropower on the Mekong Mainstream: Summary of the Final Report*, MRC, 2010, p.9.

[1058] Evelyn Goh, China in the Mekong River Basin: The Regional Security Implications of Resource Development on the Lancang Jiang, Nanyang Technological University, 2004, p.1.

[1059] Alex Smajgl & John Ward, "Mekong Region Connectivity," in A. Smajgl & J. Ward, eds. The Water-Food-Energy Nexus in the Mekong Region: Assessing Development Strategies Considering Cross-Sectoral and Transboundary Impacts, 2013, p.6; International Centre for Environmental Management, Strategic Environmental Assessment of Hydropower on the Mekong Mainstream: Summary of the Final Report, MRC, 2010, p.9.

[1060] International Centre for Environmental Management, *Strategic Environmental Assessment of Hydropower on the Mekong Mainstream: Summary of the Final Report*, MRC, 2010, pp.10-11.

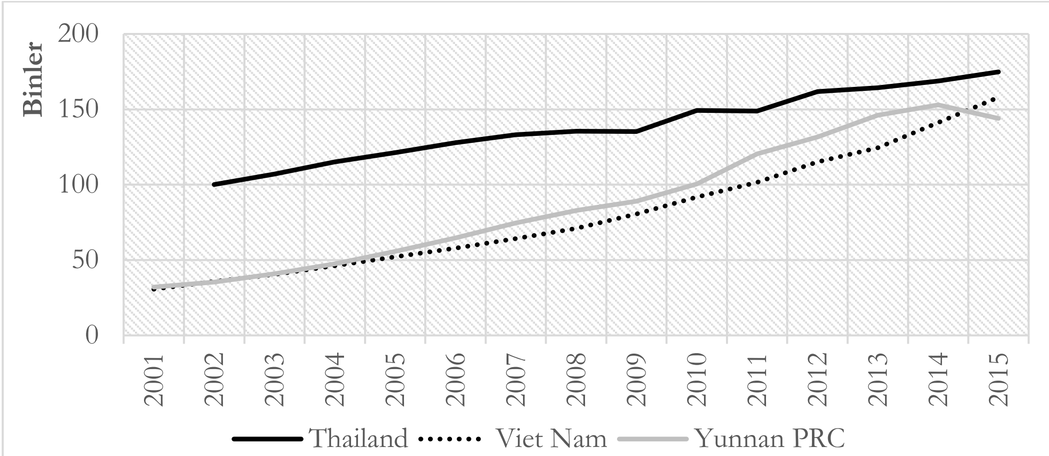

Figure 5.7. Electricity consumption in Thailand, Viet Nam and Yunnan[1061]

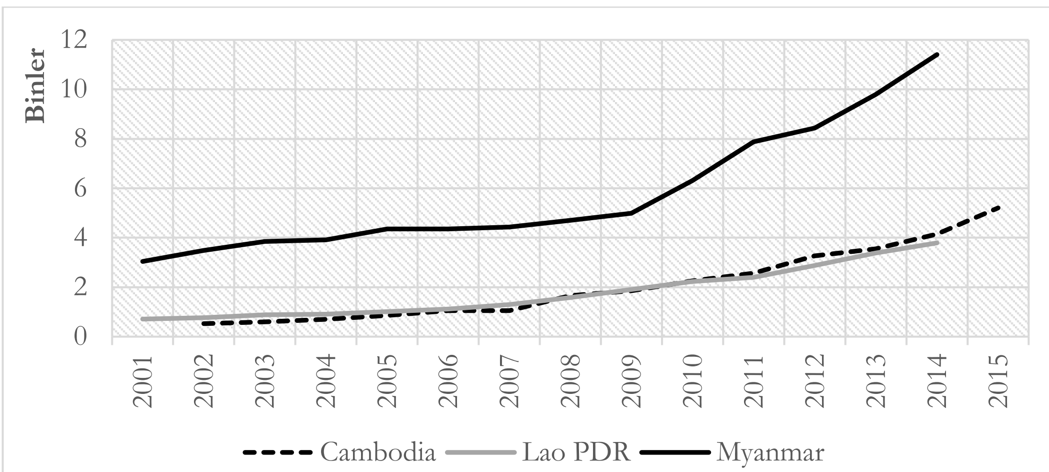

Figure 5.8. Electricity consumption in Cambodia, Laos and Myanmar[1062]

1061 In GWh. GMS, "Electricity consumption," *GMS Information Portal*, 2015, available at: http://portal.gms-eoc.org/charts/all/electricity-consumption?gid=19&gideoc=2&regoreoc=1 (accessed 19 July 2017).

1062 In GWh. GMS, "Electricity consumption," *GMS Information Portal*, 2015, available at: http://portal.gms-eoc.org/charts/all/electricity-consumption?gid=19&gideoc=2&regoreoc=1 (accessed 19 July 2017).

The electricity demand centers in the Mekong region, the two provinces of China, Thailand and Viet Nam, consumed about 610 TWh of electricity in 2015.[1063] According to estimates, Viet Nam and Thailand will have the most power demands by 2025. Viet Nam will require more than 450 TWh of electricity produced annually, while Thailand would require about 340 TWh. This means that the total regional demand would reach to 820 TWh per year. If completed, the 12 mainstream HPP projects in the Lower Mekong River basin will produce about 65 TWh of electricity per year. Thailand and Viet Nam will be net importers of 53 TWh hydroelectricity from Cambodia and Laos.[1064] Witoon Permpongsacharoen, the director of the Mekong Energy and Ecology Network, criticizes the forecasting methodology. According to the director, the electricity demand is calculated for the peak demand, and the peak demand is usually temporary. The methodology used for estimating demand leads to "inflated demand and over-projections."[1065] The methodology and principles behind the hydrological modelling for the Mekong River basin employed in the reports prepared for the major development agencies, such as the ADB and the World Bank, are subject to further criticism.[1066]

For these forecasts to be turned into reality, a number of new infrastructure development projects must be undergone. As stated above, China has renewed most of

[1063] GMS, "Electricity consumption," *GMS Information Portal*, 2015, available at: http://portal.gms-eoc.org/charts/all/electricity-consumption?gid=19&gideoc=2&regoreoc=1 (accessed 19 July 2017).

[1064] International Centre for Environmental Management, *Strategic Environmental Assessment of Hydropower on the Mekong Mainstream: Summary of the Final Report*, MRC, 2010, p.9.

[1065] Witoon Permpongsacharoen, "Interview: Toward More Democratic Power Planning in the Mekong Region," *World Rivers Review*, vol. 29, no. 4, 2014, p.12.

[1066] Carl Middleton, Jelson Garcia & Tira Foran, "Old and new hydropower players in the Mekong region: Agendas and strategies," in F. Molle, T. Foran & M. Käkönen, eds. *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance*, 2009, p.24; Mira Käkönen & Philip Hirsch, "The Anti-Politics of Mekong Knowledge Production," in F. Molle, T. Foran & M. Käkönen, eds. *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance*, 2009, pp.337-44.

its domestic transmission line infrastructure in the region. Further transnational interconnection investments are both needed and planned (Figure 5.10), as discussed further below.

5.4.2. Interconnections

As stated above, Russia and China began cooperation on energy and electricity sectors since the 2000s. In the 2010s, the volume of electricity trade between Russia and China increased. Russian electricity exports to China was 1.24 TWh in 2011, 2.63 TWh in 2012, and 3.4 TWh in 2014 (Figure 5.9).[1067] In the beginning of the 2010s, the Chinese State Grid Corporation signed an agreement with the Russian electricity exporter, the Eastern Energy Company, which will be valid for a quarter century. The main line between Russia and China is the Amurskaya-Heihe 500 kV transmission line, completed before the conclusion of the agreement in 2011.[1068]

The financing and construction of the line, “the first international ultra-high voltage transmission line connecting the Russian Far East and northeastern China,” was completed by the Eastern Energy Company.[1069] Electricity trade took place between Russia and China long before the construction of the Amurskaya-Heihe line. As early as in 1992, the 110 kV Blagoveschensk-Heihe transmission line transferred about 30 to 160 million kWh of electricity to China on an annual basis.[1070] The 1,330 megawatts Zeya and the 2,010 megawatts Bureya HPPs on the Amur River in Russia are the major generators in this interconnection. Additional 320

[1067] Shi Ze, "Building Strong China-Russia Energy Strategic Partnership," *CIIS*, 2015, available at: http://www.ciis.org.cn/english/2015-12/02/content_8422032.htm (accessed 4 January 2018).

[1068] Jenny Johnson, "Russia’s Siberian dams power “electric boilers” in Beijing," *Chinadialogue*, 2012, available at: https://www.chinadialogue.net/article/show/single/en/5384-Russia-s-Siberian-dams-power-electric-boilers-in-Beijing (accessed 5 January 2018).

[1069] Eastern Energy Company, "About Eastern Energy Company," *Eastern Energy Company*, 2016, available at: http://www.eastern-ec.ru/en/about_company/ (accessed 4 January 2018).

[1070] Eastern Energy Company, "History," *Eastern Energy Company*, 2016, available at: http://www.eastern-ec.ru/en/about_company/history/ (accessed 6 January 2018).

megawatts production capacity is planned to be provided by the Nizhne-Bureya HPP.[1071]

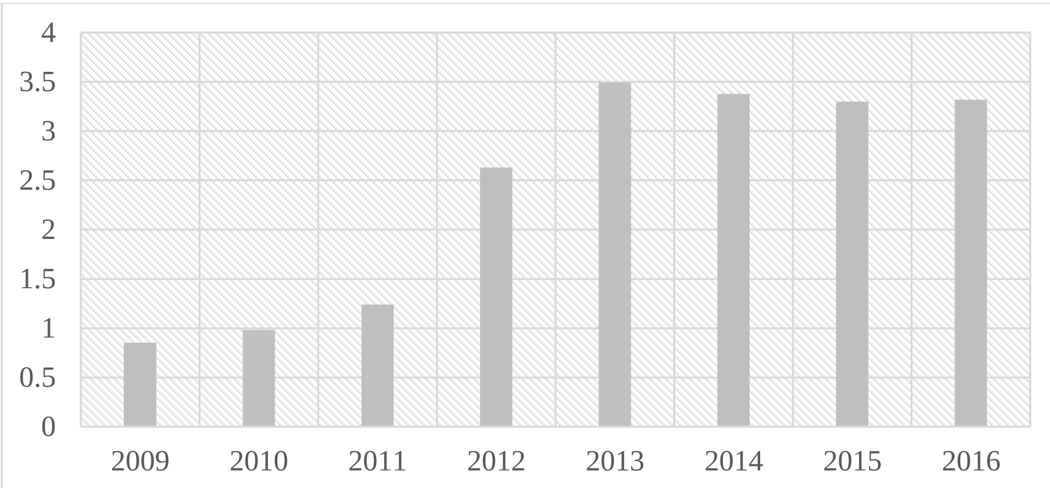

Figure 5.9. Russian electricity exports to China, TWh[1072]

In 2011, a joint venture was established between the largest private energy company of Russia, EuroSibEnergo, and the Chinese hydropower giant China Yangtze Power, which operates the HPPs at the Three Gorges Dam, as well as the Gezhouba, Xiluodu, and Xiangjiaba HPPs.[1073] EuroSibEnergo operates the Boguchanskaya

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[1071] Asia International Grid Connection Study Group, *Interim Report*, Renewable Energy Institute, 2017, available at: https://www.renewable-ei.org/en/activities/reports/img/20170419/ASGInterimReport_170419_Web_en.pdf (accessed 8 January 2018), p.36.

[1072] Inter RAO UES, "Trading," *Inter RAO UES*, 2018, available at: http://www.interrao.ru/en/activity/traiding/ (accessed 4 January 2018); Eastern Energy Company, "About Eastern Energy Company," *Eastern Energy Company*, 2016, available at: http://www.eastern-ec.ru/en/about_company/ (accessed 4 January 2018); Shi Ze, "Building Strong China-Russia Energy Strategic Partnership," *CIIS*, 2015, available at: http://www.ciis.org.cn/english/2015-12/02/content_8422032.htm (accessed 4 January 2018).

[1073] Financial Times, "China Yangtze Power Co Ltd," *Financial Times*, 2018, available at: https://markets.ft.com/data/equities/tearsheet/profile?s=600900:SHH (accessed 5 January 2018).

dam and HPP, a giant project dating back to the late Soviet era.[1074] The Russian-Chinese joint venture plans to construct new HPPs that may export excess electricity to China after supplying the local industrial ventures.[1075] The most important and most controversial project of this international venture has been the Shilka HPP, also known as the Trans-Siberian HPP, proposed to be built on the Shilka River, a tributary of the Amur River.[1076]

The interconnections between Russia and China are planned to be a part of the greater "Asia Super Grid."[1077] The grid includes Russia, China, Mongolia, Japan, and South Korea. The wind energy generated in the Gobi Desert, Mongolia, and hydroelectricity produced in Irkutsk, Russia, are transferred to Japan, China and South Korea through high-voltage transmission lines. The Asia Super Grid is a pro-

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[1074] RusHydro, "Boguchanskaya HPP," *Rushydro*, 2017, available at: http://www.eng.rushydro.ru/industry/invest/key_projects/boguchanskaya_hpp/ (accessed 6 January 2018).

[1075] Jenny Johnson, "Russia's Siberian dams power "electric boilers" in Beijing," *Chinadialogue*, 2012, available at: https://www.chinadialogue.net/article/show/single/en/5384-Russia-s-Siberian-dams-power-electric-boilers-in-Beijing (accessed 5 January 2018).

[1076] Rivers without Boundaries, "Shilka Hydro – a week of protests results in constructive outcome," *Transrivers.org*, 2012, available at: http://www.transrivers.org/2012/554/ (accessed 4 January 2018).

[1077] Igor Dzhurko, "State program of socio-economic development of the Far East and the Baikal region as a prerequisite for Asia Pacific region global energy integration," 2013, pp.10-12; Zhenya Liu, *Global Energy Interconnection* (Amsterdam: Elsevier, 2015), p.205.

ject of the Renewable Energy Institute, founded by Masayoshi Son, a Japanese entrepreneur, in 2011.[1078] More recently, the South Korean government announced support for this project.[1079]

The electricity trade between China and Mongolia takes place through a 220 kV transmission line between the Oyu Tolgoi copper mine in Mongolia and the Inner Mongolia province of China. Mongolia is dependent on external resources for electricity. As of 2015, the total imported electricity was about one quarter of total domestic generation.[1080]

Despite all debates on ecological and socioeconomic impacts of large dam projects in the Mekong basin, hydroelectricity production, interstate electricity trade, and a regional open market of electricity have been important items on the agenda of the international organizations, especially of the GMS, since the 1990s.[1081] In 1995, a

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[1078] Junko Movellan, "The Asia Super Grid – Four Countries Join Together to Maximize Renewable Energy," *Renewable Energy World*, 2016, available at: http://www.renewableenergyworld.com/articles/2016/10/the-asia-super-grid-countries-join-together-to-maximize-renewable-energy.html (accessed 4 January 2018). See also: Renewable Energy Institute, "About "Asia Super Grid (ASG)"," *Renewable Energy Institute*, 2017, available at: https://www.renewable-ei.org/en/asg/about/ (accessed 8 January 2018). See, for a detailed technical feasibility report of the project: Shuta Mano, et al., *Gobitec and Asian Super Grid for Renewable Energies in Northeast Asia*, Energy Charter Secretariat and the Energy Economics Institute of the Republic of Korea, 2014, available at: https://www.renewable-ei.org/en/images/pdf/20140124/Gobitec_and_ASG_report_ENG_BOOK.pdf (accessed 8 January 2018). For an update interim report, see: Asia International Grid Connection Study Group, *Interim Report*, Renewable Energy Institute, 2017, available at: https://www.renewable-ei.org/en/activities/reports/img/20170419/ASGInterimReport_170419_Web_en.pdf (accessed 8 January 2018).

[1079] Bryan Harris, Song Jung-a & Peter Wells, "Plan for north-east Asian electricity 'super grid' boosted," *Financial Times*, 2017, available at: https://www.ft.com/content/4b04ed8e-bf8b-11e7-b8a3-38a6e068f464 (accessed 5 January 2018).

[1080] Asia International Grid Connection Study Group, *Interim Report*, Renewable Energy Institute, 2017, available at: https://www.renewable-ei.org/en/activities/reports/img/20170419/ASGInterimReport_170419_Web_en.pdf (accessed 8 January 2018), p.34.

[1081] Carl Middleton, Jelson Garcia & Tira Foran, "Old and new hydropower players in the Mekong region: Agendas and strategies," in F. Molle, T. Foran & M. Käkönen, eds. *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance*, 2009, p.28.

"Subregional Energy Sector Study" was conducted which is followed by the establishment of "Subregional Electric Power Forum" in the same year.[1082] With the contribution of the World Bank, HPP projects were also studied, and the need for a power trade framework was stressed in 1998. In this year, the "Experts Group on Power Interconnection and Trade" was established.[1083]

The ADB has been studying plans for the Mekong River basin hydropower development as well. In 2002, it drafted a comprehensive report suggesting the building of 12 large dams and electricity transmission networks in China, Cambodia, Laos and Myanmar. The total cost of the project was estimated at 43 billion US dollars.[1084] The plans of those 12 dams were an important items on the agenda of the first meeting of the GMS in 2002 when the representatives of the Mekong region governments signed the Intergovernmental Agreement on Regional Power Trade.[1085]

[1082] GMS Secretary, "First Meeting of the Regional Power Trade Coordination Committee (RPTCC-1)," in *Summary of Proceedings*., 2004, p.2.

[1083] GMS Secretary, "First Meeting of the Regional Power Trade Coordination Committee (RPTCC-1)," in *Summary of Proceedings*., 2004, p.3.

[1084] Carl Middleton, Jelson Garcia & Tira Foran, "Old and new hydropower players in the Mekong region: Agendas and strategies," in F. Molle, T. Foran & M. Käkönen, eds. *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance*, 2009, p.28.

[1085] Carl Middleton, Jelson Garcia & Tira Foran, "Old and new hydropower players in the Mekong region: Agendas and strategies," in F. Molle, T. Foran & M. Käkönen, eds. *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance*, 2009, p.28.

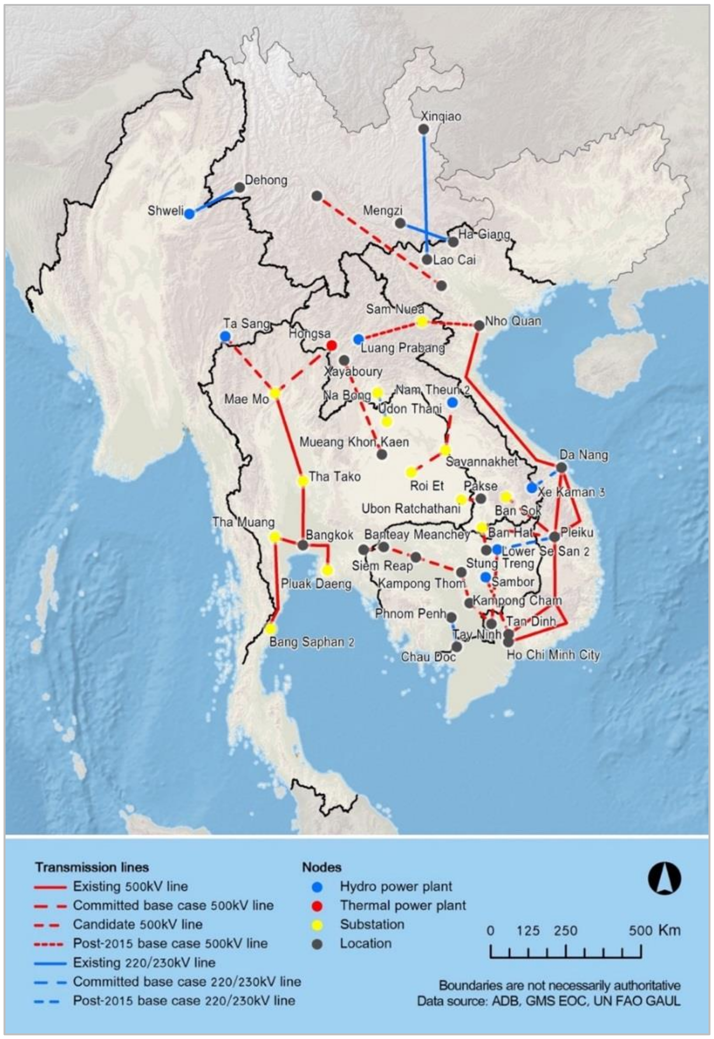

Figure 5.10. A map of the power grid in the Lower Mekong basin[1086]

The most important exporter of electricity in the Mekong River basin is the Yunnan province of China with about 95 TWh of net electricity exports, most of which is sent to the east of China, to Guangdong through ultra-high voltage transmission lines. Therefore, the largest electricity exporter is Laos, which exports most of the

[1086] GMS, "GMS Crossborder Power Transmission," *GMS Information Portal*, 2017, available at: http://portal.gms-eoc.org/uploads/map/archives/map/GMS-PowerIntercon_22_hi-res_8.jpg (accessed 30 April 2017).

generated electricity to Thailand.[1087] For the less developed countries in the region, the growing demand from Viet Nam and Thailand is an opportunity for boosting their economic growth (Table 5-5).

The GMS Regional Power Trade Coordination Committee has regularly been convening since its first meeting in Guilin, China, in July 2004. The representatives of Cambodia, China, Laos, Thailand and Viet Nam participated in this first meeting. The participants stressed the benefits of regional power trade.[1088] The Chinese government commissioned China Southern Power Grid Company as its agent for the interconnection efforts.[1089] On the agenda was the 500 kV interconnection developments between Laos, China, and Thailand; the interconnection between Laos and Viet Nam; and the 500 kV interconnection between China and Viet Nam.[1090] Later on, the project of a 600 kV interconnection between China and Thailand was also added on the agenda.[1091] Currently, the Chinese electricity grid is connected with Viet Nam through three 220 kV and two 110 kV power lines, and with Burma through one 500 kV and one 220 kV lines.[1092]

[1087] Darrin Magee & Thomas Hennig, "Hydropower boom in China and along Asia's rivers outpaces regional electricity demand," *thethirdpole.net*, 2017 (accessed 12 October 2017).

[1088] GMS Secretary, "First Meeting of the Regional Power Trade Coordination Committee (RPTCC-1)," in *Summary of Proceedings*., 2004, pp.1-3.

[1089] GMS Secretary, "Second Meeting of the Regional Power Trade Coordination Committee (RPTCC-2)," in *Summary of Proceedings*., 2004, p.2.

[1090] GMS Secretary, "Second Meeting of the Regional Power Trade Coordination Committee (RPTCC-2)," in *Summary of Proceedings*., 2004, p.7; GMS Secretary, "Fourth Meeting of the Regional Power Trade Coordination Committee (RPTCC-4)," in *Summary of Proceedings*., 2005, pp.8-9; GMS Secretary, "Fourth Meeting of the Focal Group (FG-4) of the Regional Power Trade Coordination Committee (RPTCC)," in *Summary of Discussions*., 2007, pp.2-3.

[1091] GMS Secretary, "16th Meeting of the GMS Regional Power Trade Coordination Committee (RPTCC-16)," in *Summary of Discussions*., 2014, p.3.

[1092] International Electrotechnical Commission, *Global Energy Interconnection*, International Electrotechnical Commission, 2017, available at: http://www.iec.ch/whitepaper/pdf/iecWP-globalenergyinterconnection.pdf (accessed 10 October 2017), p.41.

Table 5-5. Energy trade in the Mekong region[1093]

Electricity Trade	**Start year**	**Power subject to trade according to contracts (in megawatts)**
From Laos to Thailand		
Theun Hinboun	1998	220
Houay No	1999	126
Nam Theun 2	2010	948
Nam Ngum 2	2011	597
Theun Hinboun – expansion	2012	220
Hongsa Lignite	2015	1,437
Xayabouri	2019	1,220
From Laos to Viet Nam		
Xekaman	2012	250
Xekaman 1	2015	322
From Thailand to Cambodia		32.68
From Viet Nam to Cambodia		111.25
From China to Viet Nam	2007	700

[1093] Sunee Moungcharoen, *Following the Money Trail of Mekong Energy Industry*, Mekong Energy and Ecology Network, 2013, p.3.

In the second and third meetings of the Regional Power Trade Coordination Committee, the drafts of the regional power trade operating agreement were discussed,[1094] and the implementation of the first stage of the agreement was subject to the fourth meeting held in Myanmar in September 2005. A focal group and a planning working group were established and commissioned for the implementation of the latter.[1095] In the 2010s, China associated the electricity interconnection projects with its "One Belt and One Road" initiative. This point was stressed at the Committee meetings.[1096]

The establishment of regional organizations with the full participation of all the basin states, such as the GMS, and the international support from multinational bodies, such as the ADB and the World Bank, are major indicators of the importance of hydroelectricity for the governments. One motivation for the international organizations to support interregional electricity trade is to hinder the resurgence of historical interstate conflicts by boosting regional cooperation through economic interdependence.[1097]

The Yunnan province of China and Laos are net hydroelectricity exporters. Here, the growing economy of Thailand and its increasing electricity demand can be and will be met by the HPP projects initiated by the governments of Laos, Cambodia,[1098] and Myanmar, or from the upstream dams on the mainstream Mekong River built

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[1094] GMS Secretary, "Third Meeting of the Regional Power Trade Coordination Committee (RPTCC-3)," in *Summary of Proceedings*., 2005, p.2.

[1095] GMS Secretary, "Fourth Meeting of the Regional Power Trade Coordination Committee (RPTCC-4)," in *Summary of Proceedings*., 2005.

[1096] GMS Secretary, "18th Meeting of the GMS Regional Power Trade Coordination Committee (RPTCC-18)," in *Summary of Discussions*., 2015, p.4.

[1097] Blake Ratner, "The Politics of Regional Governance in the Mekong River Basin," *Global Change Peace & Security*, vol. 15, no. 1, 2003, p.61.

[1098] Katri Mehtonen, "Do the Downstream Countries Oppose the Upstream Dams?," in M. Kummu, M. Keskinen & O. Varis, eds. *Modern Myths of the Mekong: A Critical Review of Water and Development Concepts, Principles and Policies*, 2008, p.165.

by China. Thailand is so eager for transboundary electricity trade that the Thai government supports the HPP projects either in China, or in Myanmar and Laos.[1099] The Thai government has another motivation for importing electricity from Laos. There is a strong domestic opposition in the country against further development of the hydropower projects.[1100] Another electricity importer is Viet Nam: the country has exploited its hydropower potential almost fully, and the government of Viet Nam initiated joint dam projects with Laos.[1101] Like in Thailand, large HPP schemes in Viet Nam met strong public opposition.[1102]

The government of Laos signed memoranda of understanding with the governments of Thailand and Viet Nam. These entail the export of 7,000 megawatts of electricity to Thailand and 3,000 megawatts to Viet Nam. The companies from Thailand are also interested in the Laotian hydropower development projects. They hold shares in the World Bank-supported Nam Theun-2 HPP project and developed most of the Nam Ngum-2 scheme. By the end of the 2000s, about two thirds of the total electricity generated in Laos was exported to Thailand.[1103] There are at least ten projects

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1099 Claudia Kuenzer, et al., "Understanding the Impact of Hydropower Developments in the Context of Upstream–Downstream Relations in the Mekong River Basin," *Sustainability Science*, vol. 8, no. 4, 2013, p.576.

1100 Carl Middleton, Jelson Garcia & Tira Foran, "Old and new hydropower players in the Mekong region: Agendas and strategies," in F. Molle, T. Foran & M. Käkönen, eds. *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance*, 2009, p.24.

1101 Claudia Kuenzer, et al., "Understanding the Impact of Hydropower Developments in the Context of Upstream–Downstream Relations in the Mekong River Basin," *Sustainability Science*, vol. 8, no. 4, 2013, p.577; Katri Mehtonen, "Do the Downstream Countries Oppose the Upstream Dams?," in M. Kummu, M. Keskinen & O. Varis, eds. *Modern Myths of the Mekong: A Critical Review of Water and Development Concepts, Principles and Policies*, 2008, p.166.

1102 Carl Middleton, Jelson Garcia & Tira Foran, "Old and new hydropower players in the Mekong region: Agendas and strategies," in F. Molle, T. Foran & M. Käkönen, eds. *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance*, 2009, p.37.

1103 Joakim Ojendal & Kurt Jensen, "Politics and Development of the Mekong River Basin: Transboundary Dilemmas and Participatory Ambitions," in J. Öjendal, S. Hansson & S. Hellberg, eds. *Politics and Development in a Transboundary Watershed: The Case of the Lower Mekong Basin*, 2012, p.45; Carl Middleton, Jelson Garcia & Tira Foran, "Old and new hydropower players in the Mekong region: Agendas and strategies," in F. Molle, T. Foran & M. Käkönen, eds.

in Laos that export electricity to Thailand. The total installed capacity of the all projects were 6,636.80 megawatts as of 2013. The private companies from Thailand own about two thirds of this total installed capacity, the Laotian government has 21 percent and multinational companies own about 15 percent. The three largest Thai companies that operate in the Laotian energy business are Ratchaburi Holding, Ch Kamchang, and Banpu, which also support construction of controversial dams such as the Xayabouri Dam in Laos.[1104]

Construction of large HPPs and exporting electricity to the developing demand centers are perceived as great opportunities for development and sources of revenue for the governments of the less developed countries in the Southeast Asia, especially for Cambodia and Laos. The Nam Ngum-1 Dam in Laos exports about 70-80 percent of its total generated electricity to Thailand since early 1970s.[1105] The donors from the Western countries as well as the international organizations such as the World Bank, the ADB, the UNDP all recommend Laos developing its hydropower potential for development.[1106]

In the Irrawaddy and Salween River basins, there is a significant electricity trade taking place between China and Myanmar. The electricity exchange is possible through two high-voltage transmission lines between Myanmar and China. One is a 500 kV, 8.6 kilometers long line between the Dapein-1 HPP and Yunnan province of China. The other line is a two-circuit 220 kV line between the Shweli-1 HPP in

Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance, 2009, p.33; Sunee Moungcharoen, *Following the Money Trail of Mekong Energy Industry*, Mekong Energy and Ecology Network, 2013, p.1.

[1104] Sunee Moungcharoen, *Following the Money Trail of Mekong Energy Industry*, Mekong Energy and Ecology Network, 2013, pp.12-13.

[1105] Carl Middleton, Jelson Garcia & Tira Foran, "Old and new hydropower players in the Mekong region: Agendas and strategies," in F. Molle, T. Foran & M. Käkönen, eds. *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance*, 2009, p.27.

[1106] Carl Middleton, Jelson Garcia & Tira Foran, "Old and new hydropower players in the Mekong region: Agendas and strategies," in F. Molle, T. Foran & M. Käkönen, eds. *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance*, 2009, pp.33-34.

Myanmar and the Yunnan province of China. The electricity trade through these lines began as of August 2008 and as of end-2015, more than 12 thousand GWh of electricity is exported by Myanmar to China.[1107] There are two more 110 kV transmission lines that connect Yunnan with Myanmar and are ready for operation since 2015. As of 2017, these lines require intergovernmental agreement for beginning operation.[1108]

The growing electricity trade in the region does not continue without problems. The trade relations have become subject to criticism given the continuation of high levels of poverty in the downstream countries. The critiques argue that the poor are not the beneficiaries of the power trade, and instead, they suffer from the negative consequences of the deteriorating ecological and hydrological regimes.[1109]

Mehtonen argues that while it seems that the governments of the downstream countries have concerns for the HPP development projects upstream in China's Yunnan province, the governments of the downstream countries are interested in cross-border electricity trade. Especially Thailand, Laos and Viet Nam demand to import electricity produced in Yunnan. Also, Cambodia desires to import electricity from the HPPs constructed by China on the Salween River. In addition, the potential for hydroelectricity trade is high among other countries in the region, and the international and regional bodies support investments in hydropower production and cross-

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[1107] IFC, MOEE and MONREC, *Strategic Environmental Assessment (SEA) of the Hydropower Sector: Baseline Assessment Reports*, 2017, available at: http://www.ifc.org/wps/wcm/connect/3f136d35-74fe-4601-90f8-4a03c4d22a2b/Chapter+2_Hydro+-+Baseline+Assessment+report+-+06+Oct.pdf?MOD=AJPERES (accessed 6 January 2018), p.15.

[1108] IFC, MOEE and MONREC, *Strategic Environmental Assessment (SEA) of the Hydropower Sector: Baseline Assessment Reports*, 2017, available at: http://www.ifc.org/wps/wcm/connect/3f136d35-74fe-4601-90f8-4a03c4d22a2b/Chapter+2_Hydro+-+Baseline+Assessment+report+-+06+Oct.pdf?MOD=AJPERES (accessed 6 January 2018), pp.15-16.

[1109] Claudia Kuenzer, et al., "Understanding the Impact of Hydropower Developments in the Context of Upstream–Downstream Relations in the Mekong River Basin," *Sustainability Science*, vol. 8, no. 4, 2013, p.579.

border electricity trade. It is the rural and poor people of the downstream countries that suffer most from the large development projects, not the governments.[1110]

5.5. Conclusion

Especially after the end of the Cold War, the economies of South and Southeast Asia recorded significant growth figures, and in parallel, the importance of energy and its trade increased. The economic development in some regional countries, especially China, Thailand, Viet Nam, or India have had a considerable impact on this situation as the level of cross-border electricity trade has been increasing steadily since the early 2000s with the support of the international and regional development agencies.

Today, China is the second largest economy and the largest hydroelectricity producer in the world. It shares a considerable high number of transboundary water bodies with numerous neighbors and riparians in quite varying climate, geography, and social conditions. While population and economic activity density is low in the northern transboundary river basins, the situation is almost the opposite in the south. The abundance of water and low population density in the north decreases the level of transboundary issue areas here. The hydropolitical situation in the south is a bit more complicated as some major regional rivers, such as the Mekong, the Brahmaputra, or the Indus, which originate from the Tibetan Plateau within the political borders of China, are shared with a number of riparians. In all these river basins, which are in political and economic hotspots of the world, there are water-related problems originating from the unilateral water development projects of China.

Along with the least developed countries in South Asia, China bids for being a regional battery and establish regional common grids. While these projects tend to

[1110] Katri Mehtonen, "Do the Downstream Countries Oppose the Upstream Dams?," in M. Kummu, M. Keskinen & O. Varis, eds. *Modern Myths of the Mekong: A Critical Review of Water and Development Concepts, Principles and Policies*, 2008, pp.168-69. See also: Blake Ratner, "The Politics of Regional Governance in the Mekong River Basin," *Global Change Peace & Security*, vol. 15, no. 1, 2003, p.64.

increase the power generation and transmission infrastructure and may contribute to regional economic growth, the impact on people and the fragile and unique ecosystem should also be taken into consideration. China already possesses the largest hydroelectricity installed capacity in the world and aims to meet an important portion of the increasing electricity demand from hydropower. In this respect, emerging countries in Southeast and South Asia, such as China, India, Thailand, or Viet Nam may meet their domestic energy demands from the network of HPPs installed on major transboundary rivers both within and without the borders of China. This increased hydropower trade, in turn, may contribute to the solution of regional hydropolitical problems.

CHAPTER VI

KYRGYZSTAN

> Can a pagan Communist nation, […] by enslaving and regimenting its people, make more efficient use of soil and water resources than the most advanced and enlightened nation in the world? Can ruthless atheists mobilize and harness their treasures of God-given wealth to defeat and stifle freedom-loving peoples everywhere?
>
> Robert Kerr, quoted in Worster, 1985

6.1. Introduction

One of the most important problems in the post-Soviet Central Asia has been water and hydroelectricity production dilemma. The description of the problem is simple: The downstream countries need water for their large irrigated agriculture sector, while the upstream countries demand water for hydroelectricity generation, both for meeting domestic demand, and for boosting their economic growth through exports. But the solution is tougher than it appears.

After the dissolution of the Soviet Union, Central Asia has been on the agenda of international politics with tense hydropolitical relations between the riparian countries in the Aral Sea basin, along with an unfortunate environmental crisis.[1111] Cotton cultivation and energy transactions between the riparians were parts of these disputes, often reflected in the reports of international organizations and other institutions.[1112] To facilitate the solution of the problem, many actors assumed intermediary roles and tried to support a number of regional projects.[1113]

Until recently, there were no serious development towards a sustainable solution of the water problem in the Aral Sea basin. On the other hand, after a change of leadership in Uzbekistan, some promising steps were taken towards regional cooperation. This chapter focuses on the hydroelectricity and irrigated agriculture issues with a special emphasis on the Aral Sea basin. Then, the electricity trade in Central Asia will be analyzed.

1111 See: Freedman, E. & Neuzil, M., eds., *Environmental Crises in Central Asia: From Steppes to Seas, from Deserts to Glaciers* (London and New York: Routledge, 2016). See, for a comprehensive technical report on the environmental status of the Aral Sea and its coastal zone: Hans Nachtnebel, et al., *The rehabilitation of the ecosystem and bioproductivity of the Aral Sea under conditions of water scarcity*, International Association for the promotion of co-operation with scientists from the New Independent States of the former Soviet Union, 2006.

1112 See, for example: World Energy Council, *Electricity in Central Asia: Market and Investment Opportunity Report*, 2007, available at: https://www.worldenergy.org/wp-content/uploads/2012/10/PUB_Asia_Regional_Report_Electricty_Market_And_Investment_Opportunity_2007_WEC.pdf (accessed 17 November 2015); Siegfried Grunwald, *Central Asia Regional Economic Cooperation: Power Sector Regional Master Plan*, Asian Development Bank, 2012, available at: http://www.adb.org/projects/documents/central-asia-regional-economic-cooperation-power-sector-regional-master-plan-tacr (accessed 17 November 2015).

1113 See, for example: UNDP/GEF, *The UNDP-GEF Project "Small Hydropower Development": Global Challenges, National Problems and Solutions, 2010-2015*, 2015; World Bank, "North-South Electricity Transmission Project," *The World Bank*, 2012, available at: http://projects.worldbank.org/P095155/north-south-electricity-transmission-project?lang=en (accessed 22 May 2017); Islamic Development Bank, *Mini Hydropower Plants Brighten Rural Tajikistan*, Islamic Development Bank, 2013; EC IFAS, "EC IFAS Partners," *IFAS*, 2011, available at: http://ec-ifas.waterunites-ca.org/about/partners/index.html (accessed 23 May 2017).

6.2. Physical characteristics

The Aral Sea catchment area is an endorheic basin. Aridity and environmental degradation are the most prominent features of the basin, which is surrounded by deserts and mountains of inner Asia. These landscapes establish natural barriers for Central Asian waters in their journey towards open sea. The largest reservoir into which the majority of regional waters are discharged through the two large water highways of the region, the Amu Darya and the Syr Darya, is the Aral Sea, which has no outlet to another body of water.

Today, the Aral Sea almost ceased to exist, as a consequence of an uninterrupted pressure on regional waters since the late Soviet era, largely because of poor water and agricultural policies of the Union countries. At about 10 percent of its original size, the Aral Sea gives the large endorheic basin its name.

6.2.1. Geography and main regional features

Geographically, many countries may be involved into the boundaries of Central Asia. In this chapter, it refers to five former Soviet republics, Kazakhstan, Kyrgyzstan, Uzbekistan, Turkmenistan, and Tajikistan. The major water catchment in the region is the Aral Sea basin, the largest endorheic basin in Central Asia, with wider than 1.2 million square kilometers drainage area. The two major rivers, the Amu Darya and the Syr Darya, drain the water of the region into the Aral Sea, once one of the largest lakes in the world, shared by Kazakhstan and Uzbekistan. Nine countries share the Aral Sea basin, Afghanistan, China, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan, and small parts of Pakistan and India. This chapter focuses on the five Central Asian republics in general, and on Kyrgyzstan, in particular. The land areas and populations of China, Pakistan, and India within the basin are so marginal that they are excluded from scrutiny in this chapter.

Among the basin countries, Kazakhstan has by far the largest surface area, more than 2.7 million square kilometers land area. It is followed by Afghanistan (about 650 thousand square kilometers), Turkmenistan (about 490 thousand square kilometers), Uzbekistan (about 450 thousand square kilometers), Kyrgyzstan (about 200 thousand square kilometers), and Tajikistan (about 140 thousand square kilometers). The most populous among the basin countries are Afghanistan and Uzbekistan, with more than 30 million inhabitants.

Turkmenistan and Uzbekistan have 95 percent of their land area within the Aral Sea basin while almost all of the Tajikistan remains in the basin. Kyrgyzstan has 59, Afghanistan 38 and Kazakhstan has 13 percent of their total land areas in the catchment area (Table 6-1).[1114]

The geography of the Aral Sea basin is dominated by the mountains in the east, the Tien Shan (or Tengri-Too, Ala-Too) and the Pamirs, and the plains, the Turan plain being the foremost, in the west. Also, there are smaller and medium-sized lakes, as well as valleys in the basin. At the western end of the basin stretches the Kara Kum desert, which covers most of the Turkmenistan. The Kyzyl Kum desert lies between the Amu Darya and the Syr Darya and shared by Kazakhstan, Turkmenistan, and Uzbekistan.

In the east of the basin are Kyrgyzstan and Tajikistan, the two mostly mountainous upstream countries of the region. Mountains cover more than 90 percent of these two countries. The northern part of Afghanistan, which remains within the Aral Sea basin, is also mostly mountainous. The Pamir Mountains of Tajikistan is famous with its glaciers. The Fedchenko Glacier here is the longest glacier in the world outside of the geographical poles. Melting glaciers are among the most important sources of water here. Tajikistan contributes more than half the river basin runoff, while Kyrgyzstan contributes one-quarter.[1115]

[1114] Food and Agriculture Organization of the United Nations, *Aral Sea Basin*, 2012, available at: http://www.fao.org/nr/water/aquastat/basins/aral-sea/aral.sea-CP_eng.pdf (accessed 21 March 2017).

[1115] Food and Agriculture Organization of the United Nations, *Aral Sea Basin*, 2012, available at: http://www.fao.org/nr/water/aquastat/basins/aral-sea/aral.sea-CP_eng.pdf (accessed 21 March 2017).

Table 6-1. Land area of the countries within the Aral Sea basin[1116]

	Aquastat	TFDD	TWAP
Afghanistan	246	105.168	166
Kazakhstan	345	425.243	358
Kyrgyzstan	118.37	111.836	119
Tajikistan	141.13	135.738	141
Turkmenistan	461.74	70.194	58
Uzbekistan	425.03	383.108	376
Total	1,737.27	1,231.287	1,218

The climate of Central Asia varies both from north to south, and from mountains towards valleys and plains. The mountainous regions of Kyrgyzstan and Tajikistan are classified as cold (continental) climate, with dry and warm summers, according to the Köppen-Geiger climate classification. The lower valleys and other parts of these countries are cold semi-arid, cold desert, and partly, warm Mediterranean climate zones. The south of Kazakhstan, the west of Uzbekistan and the west of Turkmenistan are in the cold desert climatic zone. The western part of Fergana Valley and the Jizzakh province of Uzbekistan remains within warm continental climate zone.

6.2.2. The Aral Sea and its basin

The Aral Sea basin consists of two main rivers that drain the water of the highlands in the southeast of Central Asia towards the degraded Aral Sea. These rivers are the

[1116] In thousand square kilometers. The sources in respective order: Aquastat: Food and Agriculture Organization of the United Nations, *Aral Sea Basin*, 2012, available at: http://www.fao.org/nr/water/aquastat/basins/aral-sea/aral.sea-CP_eng.pdf (accessed 21 March 2017); TFDD: Oregon State University, "Aral Sea Basin," *Transboundary Freshwater Dispute Database (TFDD)*, 2009, available at: http://gis.nacse.org/tfdd/map/result.php?bcode=ARAL (accessed 26 April 2017); TWAP: UNEP/GEF, "TWAP," *Transboundary Waters Assessment Programme*, 2017, available at: http://www.geftwap.org/twap-project (accessed 18 April 2017).

Amu Darya and the Syr Darya, and the catchment zone includes parts of the territories of Kazakhstan, Kyrgyzstan, Turkmenistan, and Afghanistan, as well as the whole of Uzbekistan and Tajikistan.[1117]

The Amu Darya is the largest river in the region in terms of average runoff: the 2,500 kilometer-long river discharges about 74-78 cubic kilometers per year. The headwaters of the Amu Darya is in the glacial mountains of Afghanistan and Tajikistan. One of the main tributaries of the Amu Darya is the Vakhsh (Kyzyl-Suu) River that originates from Kyrgyzstan and after crossing Tajikistan, confluences with the other main tributary, the Panj River, over the Afghanistan-Tajikistan border to establish the mainstream Amu Darya.[1118] The headwaters of the Panj are in the Pamir Mountains in Afghanistan. The other main tributaries on the political borderline after the confluence of Vakhsh and Panj are the Kofarnihon that passes through the Tajik capital Dushanbe and joins the mainstream on the Afghan-Tajik border; the Surkhandarya that originates from Tajikistan and flows through Uzbekistan into the mainstream around the city of Termez; the Sherabad that flows from Uzbekistan in the north-south direction towards the border; as well as the Kunduz and the Kokcha rivers that join the Amu Darya from the left flowing in south-north direction. There are no major tributaries of the Amu Darya further downstream.[1119] The Karakum Canal is the main water diversion from the mainstream Amu Darya, with an estimated diversion of 10-12 cubic kilometers of water on an annual basis. The canal also gets water from the Murgab and Tejen rivers, and feeds most of the

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[1117] Aral Sea Fund, "The Amu Darya and the Syr Darya, Central Asia's lifelines," *waterunites-ca.org*, 2017, available at: http://www.waterunites-ca.org/themes/29-the-amu-darya-and-the-syr-darya-central-asia-s-lifelines.html (accessed 15 September 2017).

[1118] Food and Agriculture Organization of the United Nations, *Aral Sea Basin*, 2012, available at: http://www.fao.org/nr/water/aquastat/basins/aral-sea/aral.sea-CP_eng.pdf (accessed 21 March 2017).

[1119] Food and Agriculture Organization of the United Nations, *Aral Sea Basin*, 2012, available at: http://www.fao.org/nr/water/aquastat/basins/aral-sea/aral.sea-CP_eng.pdf (accessed 21 March 2017).

agriculture in Turkmenistan.[1120] After the diversion, the Amu Darya flows towards northwest in the desert, establishing part of the border between Turkmenistan and Uzbekistan, and establishing the Akça Darya Delta in the south of the Aral Sea.

The Syr Darya carries about half the water carried by the Amu Darya, around 37 cubic kilometers per annum, but is longer than it, with a length of more than 3,000 kilometers.[1121] About three quarters of the Syr Darya flow originates from Kyrgyzstan, while Uzbekistan's contribution is 15.2 percent of the total runoff.[1122] The Naryn River and the Kara Darya confluence in the east of the Fergana Valley in Uzbekistan to establish the Syr Darya mainstream. Downstream of the confluence, it feeds the fertile Fergana and the so-called Golodnaya Steppe in Uzbekistan. The main tributaries of the Syr Darya is the Angren River and the Chirchik River in Uzbekistan that confluence with the mainstream from the right. After the confluence of the Chirchik River, which passes through the Uzbek capital, Tashkent, the Syr Darya leaves the Uzbek territory and enters Kazakhstan from the south. The river flows in the southeast-northwest direction until its mouth near the Aral Sea.

6.2.3. Local institutions and regulations

The legal infrastructure of the Soviet Union and the presence of a central authority to enforce the regulations guaranteed the cooperative character of the Soviet era water management. The SSRs were bound to the laws and regulations on water use and consumption. The state possessed the exclusive ownership right of all natural resources, including water. This meant that, water resources were not subject to

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[1120] Food and Agriculture Organization of the United Nations, *Aral Sea Basin*, 2012, available at: http://www.fao.org/nr/water/aquastat/basins/aral-sea/aral.sea-CP_eng.pdf (accessed 21 March 2017).

[1121] Aral Sea Fund, "The Amu Darya and the Syr Darya, Central Asia's lifelines," *waterunites-ca.org*, 2017, available at: http://www.waterunites-ca.org/themes/29-the-amu-darya-and-the-syr-darya-central-asia-s-lifelines.html (accessed 15 September 2017).

[1122] Aral Sea Fund, "Water resources of the Aral Sea Basin," *waterunites-ca.org*, 2011, available at: http://ec-ifas.waterunites-ca.org/aral_basin/index.html (accessed 13 February 2018).

civil law or regulations.[1123] Water management is regulated according to the principles of "fullest and most effective," "rational" and "complex" use of water resources. The latter involves exploitation of water "for the fulfillment of the whole complex of different requirements of all interested water users."[1124] The principal target of water regulations and laws for Central Asia was increasing the irrigated land, and the volume of cotton harvested. In the Naryn Basin, for example, about three quarters of water are released from the Toktogul Reservoir during the vegetation period annually. This release generated excess electricity, which was over the demand level for the Kyrgyz SSR, and sent into the common grid, the Central Asian Power System (CAPS). This was a system defined as a "*pseudo-nexus* experience" by some scholars.[1125] In return for excess electricity sent to the CAPS, hydrocarbon resources were sent from downstream to the upstream countries in winter.[1126]

After the collapse of the Soviet Union, the Aral Sea basin water resources have been regulated through a number of multiparty agreements. Immediately after independence in early 1992, the governments of Kazakhstan, Kyrgyzstan, Uzbekistan, Tajikistan and Turkmenistan agreed upon a text titled "Cooperation in the Field of

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[1123] Irving Fox & O. Kolbasov, *Water resources law and policy in the Soviet Union. Madison: Published for the Water Resources Center* (Wisconsin: University of Wisconsin Press, 1971), p.104.

[1124] Irving Fox & O. Kolbasov, *Water resources law and policy in the Soviet Union. Madison: Published for the Water Resources Center* (Wisconsin: University of Wisconsin Press, 1971), p.107.

[1125] Shavkat Rakhmatullaev, Iskandar Abdullaev & Jusipbek Kazbekov, "Water-Energy-Food-Environmental Nexus in Central Asia: From Transition to Transformation," in D. Barceló & A.G. Kostianoy, eds. *The Handbook of Environmental Chemistry*, 2017, p.5. Emphasis original.

[1126] World Bank, *Water and Energy Nexus in Central Asia: Improving Regional Cooperation in the Syr Darya Basin*, 2004b, available at: http://siteresources.worldbank.org/INTUZBEKISTAN/Resources/Water_Energy_Nexus_final.pdf (accessed 12 November 2015), pp.3-4.

Joint Water Resources Management and Conservation of Interstate Sources" in Almaty.[1127] This framework agreement was a demonstration of a common will for cooperation in water resources management. The agreement was designed on the principle of "equal rights to water use," and the parties agreed upon rational water use principles as used to be during the Soviet era. At the same time, this agreement founded the Interstate Commission for Water Coordination of Central Asia (ICWC), a regional body assigned the task of determining a common water policy. Regulating the reservoirs, rational water use, water allocation for irrigation and industrial use, managing annual water consumption limits of the basin states, determining compensation mechanisms, and coordinating large scale hydraulic works are among the principal duties of the ICWC. The Basin Water Associations (BWOs) were organized under the ICWC for both Amu Darya and Syr Darya basins for operational purposes. The BWOs "operate water intakes, hydro structures, reservoirs and canals."[1128]

The governments of the Central Asian states have recognized the ecological degradation in the region especially with regards to the Aral Sea problem as early as in 1993 with the agreement signed in Kzyl-Orda. With this agreement, another international organization under the name of Interstate Council on the Problems of the Aral Sea Basin was foreseen to be established with an executive committee in Tashkent.[1129] This organization ceased to exist in 1997 with the establishment of the

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[1127] "Agreement Between the Republic of Kazakhstan, the Republic of Kirgyzstan, the Republic of Uzbekistan, the Republic of Tajikistan and Turkmenistan On Cooperation in the Field of Joint Water Resources Management and Conservation of Interstate Sources" 1992, available at: http://www.icwc-aral.uz/statute1.htm (accessed 26 November 2015).

[1128] "Statute of the Interstate Commission for Water Coordination of Central Asia" 1992, available at: http://www.icwc-aral.uz/statute12.htm (accessed 25 November 2015).

[1129] "Agreement btw. Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan on joint activities in addressing the Aral Sea and the zone around the Sea crisis, improving the environment, and enduring the social and economic development of the Aral Sea reg." 1993, available at: http://www.cawater-info.net/library/eng/l/kzyl-orda_agreement.pdf (accessed 26 September 2017).

International Fund for Saving the Aral Sea (IFAS). The executive committee of the IFAS is in Almaty.[1130]

A series of agreements were signed in Bishkek in 1998, 1999, and in Bishkek and Osh in 2000 between Kazakhstan, Kyrgyzstan and Uzbekistan regulated the use of the water resources, particularly in the Naryn and Syr Darya basins.[1131] These documents set the principles on water release, production and transit of electricity and compensation for energy losses. The principles of the 1998 agreement restored the water-hydrocarbon compensation mechanism that was functional during the Soviet era. The BWOs manage the schedules of water releases and energy transfers. With the agreement, the signatories agreed upon jointly determining new HPP projects and building of further reservoirs in the basins. Intergovernmental agreements set the volume of water release from the Toktogul Reservoir and the rules of compensation from downstream countries that are in the form of hydrocarbons and electricity depending on the seasons of the year. An example of this exchange is shown in Figure 6.1.

[1130] International Fund for Saving the Aral Sea, "Who We Are," *Serving the People of Central Asia*, 2011, available at: http://ec-ifas.waterunites-ca.org/about/index.html (accessed 26 September 2017).

[1131] "Agreement Between the Government of the Republic of Kazakhstan, the Government of the Kyrgyz Republic and the Government of the Republic of Uzbekistan on Joint and Complex Use Water and Energy Resources of the Naryn Syr Darya Cascade Reservoirs in 1998" 1998, available at: http://www.ce.utexas.edu/prof/mckinney/papers/aral/agreements/Annual-Operation-98.pdf (accessed 24 November 2015); "Agreement Between the Governments of the Republic of Kazakhstan, the Kyrgyz Republic, and the Republic of Uzbekistan on the Use of Water and Energy Resources of the Syr Darya Basin" 1998, available at: http://www.ce.utexas.edu/prof/mckinney/papers/aral/agreements/syrdaryaagr-mar17-98.pdf (accessed 23 November 2015); "Agreement Between the Government of the Republic of Kazakhstan and the Government of the Kyrgyz Republic on Comprehensive Use of Water and Energy Resources of the Naryn Syr Darya Cascade Reservoirs in 1999" 1999, available at: http://www.cawater-info.net/bk/water_law/pdf/annual-kzkg-99.pdf (accessed 26 September 2017).

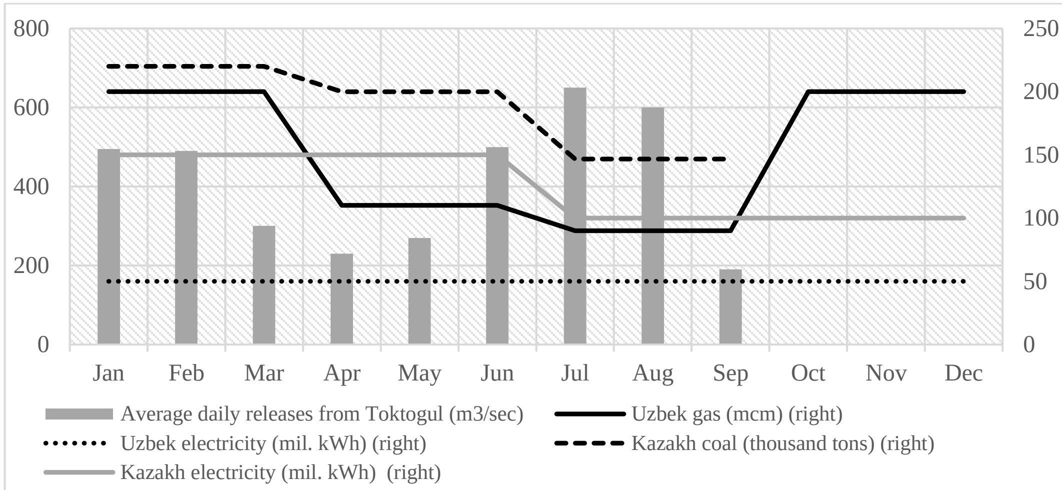

Figure 6.1. The barter mechanism based on the Toktogul reservoir (1998)[1132]

Additional bilateral agreements were signed in 1999 and 2000 between the upstream Tajikistan and downstream Uzbekistan that regulate water releases from the upstream reservoirs and the electricity transfers between the two countries.[1133]

According to the principles in the 1998 agreement, an agreement was signed in 1999 that particularly regulates the energy grid of Central Asia. Accordingly, the Central Asian states, excluding Turkmenistan, have agreed to "[…] assume the responsibility to create favorable conditions to develop and implement the advantages of a parallel operation of energy systems and restrain from actions that may damage

[1132] "Agreement Between the Government of the Republic of Kazakhstan, the Government of the Kyrgyz Republic and the Government of the Republic of Uzbekistan on Joint and Complex Use Water and Energy Resources of the Naryn Syr Darya Cascade Reservoirs in 1998" 1998, available at: http://www.ce.utexas.edu/prof/mckinney/papers/aral/agreements/Annual-Operation-98.pdf (accessed 24 November 2015).

[1133] "Agreement Between the Government of the Republic of Uzbekistan and the Government of the Republic of Tajikistan on Cooperation in the Area of Rational Water and Energy Uses in 1999" 1999, available at: http://www.cawater-info.net/bk/water_law/pdf/kayrakum-99.pdf (accessed 26 September 2017); "Agreement Between the Government of the Republic of Uzbekistan and the Government of the Republic of Tajikistan on Cooperation in the Area of Rational Water and Energy Uses in 2000" 2000, available at: http://www.cawater-info.net/bk/water_law/pdf/kayrakum-00.pdf (accessed 26 September 2017).

the interests of the other party."[1134] The states have agreed upon establishing the regional Electric Power Pool of Central Asia, which would operate through the 500 and 220 kV transmission lines between the countries.[1135]

6.3. Water development projects in the Aral Sea basin

There are significant differences between the Aral Sea basin states in terms of water management and water use. Most importantly, the economic structures and the sizes of the countries vary. Kazakhstan is the largest economy with hydrocarbon reserves, while Tajikistan ranks among the poorest countries globally. As a consequence, the importance and meaning of water changes from country to country. For Tajikistan and Kyrgyzstan, water means hydropower, while for Uzbekistan and Turkmenistan, it is a natural resource to sustain irrigated agriculture. This section scrutinizes the water dilemmas between the upstream and downstream countries in the Aral Sea basin.

6.3.1. Background

In the early irrigation works in Turkestan, around Murgab and Tejen, the limited amount of water facilitated irrigation, but large-scale irrigation could not be possible[1136] until dams, canals, and other early irrigation works appeared in the region in

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[1134] "Agreement between the Governments of the Republics of Kazakhstan, the Kyrgyz Republic, the Republic of Tajikistan, and the Republic of Uzbekistan on the Parallel Operation of the Energy Systems of Central Asia" 1999, available at: http://www.cawater-info.net/library/eng/l/parallel-agreement.pdf (accessed 26 September 2017).

[1135] "Agreement between the Governments of the Republics of Kazakhstan, the Kyrgyz Republic, the Republic of Tajikistan, and the Republic of Uzbekistan on the Parallel Operation of the Energy Systems of Central Asia" 1999, available at: http://www.cawater-info.net/library/eng/l/parallel-agreement.pdf (accessed 26 September 2017).

[1136] Robert Lewis, "Early Irrigation in West Turkestan," *Annals of the Association of American Geographers*, vol. 56, no. 3, 1966, pp.472-73; Ian Matley, "The Murgab Oasis: The Modernization of an Ancient Irrigation System," *Canadian Slavonic Papers / Revue Canadienne des Slavistes*, vol. 17, no. 2-3, Russian and Soviet Central Asia, 1975, pp.417-20.

the fourth millennium BC.[1137] In the Fergana Valley, first irrigated agriculture emerged in the second millennium BC, around Chust and Dalverzin, and the Amu Darya and the Syr Darya waters could only be developed with the help of new technologies emerged in the first millennium BC.[1138] Large agricultural settlements were founded in the Fergana Valley,[1139] and some cities, such as Merv, emerged as important centers of civilization and water management in the eleventh and twelfth centuries.[1140] By the thirteenth century, in the era of khanates and emirates (Kokand, Khiva, Bukhara), a comprehensive water management system was established in the region with agents appointed by the state, such as *aryk bashi* and *mirab*s, being in charge of water distribution.[1141]

[1137] Robert Lewis, "Early Irrigation in West Turkestan," *Annals of the Association of American Geographers*, vol. 56, no. 3, 1966, pp.472-75.

[1138] Robert Lewis, "Early Irrigation in West Turkestan," *Annals of the Association of American Geographers*, vol. 56, no. 3, 1966, p.479.

[1139] Ian Matley, "The Murgab Oasis: The Modernization of an Ancient Irrigation System," *Canadian Slavonic Papers / Revue Canadienne des Slavistes*, vol. 17, no. 2-3, Russian and Soviet Central Asia, 1975, pp.421-22; Iskandar Abdullaev & Shavkat Rakhmatullaev, "Transformation of Water Management in Central Asia: From State-Centric, Hydraulic Mission to Socio-Political Control," *Environmental Earth Sciences*, vol. 73, no. 2, 2015, p.851.

[1140] Sarah O'Hara & Tim Hannan, "Irrigation and Water Management in Turkmenistan: Past Systems, Present Problems and Future Scenarios," *Europe-Asia Studies*, vol. 511, 1999, p.24.

[1141] Iskandar Abdullaev & Shavkat Rakhmatullaev, "Transformation of Water Management in Central Asia: From State-Centric, Hydraulic Mission to Socio-Political Control," *Environmental Earth Sciences*, vol. 73, no. 2, 2015, pp.851-52. In Uzbekistan, written references to cotton growing dates back to the thirteenth century. The production of cotton, called *guzah*, continued here since then. The merchants carried the cotton on camels to Orenburg. See: Louis Michael, *Cotton Growing in the Soviet Union*, Bureau of Agricultural Economics, Danube Basin District, 1938, pp.7-8. See also: Robert Lewis, "Early Irrigation in West Turkestan," *Annals of the Association of American Geographers*, vol. 56, no. 3, 1966, pp.475-77; Sarah O'Hara & Tim Hannan, "Irrigation and Water Management in Turkmenistan: Past Systems, Present Problems and Future Scenarios," *Europe-Asia Studies*, vol. 511, 1999, p.24.

In the nineteenth century, when Russians first appeared, irrigated agriculture[1142] was conducted in some regions around the Fergana Valley and the Zeravshan.[1143] Far from its old prosperity was the Murgab oasis,[1144] whose irrigation techniques had inspired almost all the early irrigation in the ancient agricultural sites in Turkestan. A topographical survey, which began in 1870,[1145] found that the Zeravshan Valley was one of the most suitable places for irrigated agriculture and for cotton cultivation,[1146] but the first planned irrigation development took place in the Hungry (*Golodnaya*) Steppe on the Syr Darya basin, since the Zeravshan flow was evaluated as being irregular and non-voluminous.[1147]

In their initial irrigation attempts, Russian authorities tried to mobilize unpaid labor for the digging of new canals, but the resistance of native population and lack of

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1142 Rainwater and irrigated farming were both widespread in Central Asia. Rainwater farming is known as *baharikarlık* in Uzbek and *baharikari* in Tajik. Irrigated farming is called *suvli* in Uzbek and *abikari* in Tajik. See: Ian Matley, "The Golodnaya Steppe: A Russian Irrigation Venture in Central Asia," *Geographical Review*, vol. 60, no. 3, 1970, p.328.

1143 Ian Matley, "The Golodnaya Steppe: A Russian Irrigation Venture in Central Asia," *Geographical Review*, vol. 60, no. 3, 1970, p.329. See also: Kn. Massalskiy, *Khlopkovoye Delo v Srednei Azii i Ego Buduschee* (S.Peterburg: B. Kirschbaum, 1892), p.16.

1144 Ian Matley, "The Murgab Oasis: The Modernization of an Ancient Irrigation System," *Canadian Slavonic Papers / Revue Canadienne des Slavistes*, vol. 17, no. 2-3, Russian and Soviet Central Asia, 1975, p.424.

1145 The survey was conducted by Baron Aminov.

1146 Ian Matley, "The Golodnaya Steppe: A Russian Irrigation Venture in Central Asia," *Geographical Review*, vol. 60, no. 3, 1970, p.332; Maya Peterson, *Technologies of Rule: Empire, Water, and the Modernization of Central Asia, 1867-1941*, Harvard University, 2011, p.106. See also: Iskandar Abdullaev & Shavkat Rakhmatullaev, "Transformation of Water Management in Central Asia: From State-Centric, Hydraulic Mission to Socio-Political Control," *Environmental Earth Sciences*, vol. 73, no. 2, 2015, p.855.

1147 For more details on the rivers and canals in Turkestan in late nineteenth century, see: A. Shakhnazarov, *Selskoye Khozyaistvo v Turkestanskom Krai* (St. Petersburg, 1908), pp.104-06. See also: Ian Matley, "The Golodnaya Steppe: A Russian Irrigation Venture in Central Asia," *Geographical Review*, vol. 60, no. 3, 1970, pp.332-33.

planning[1148] made progress slower.[1149] Later on, the Russian administration of Turkestan abandoned the practice of unpaid labor[1150] and assigned large amounts of funds for irrigation purposes at the outset of the twentieth century. Some examples of Russian irrigation ventures in Central Asia were: The Khiva Aryk, initiated by the Grand Duke Nikolay Konstantinovich Romanov in 1891 and finished in 1898, to be renamed Imperator Nikolay I Canal;[1151] the project of the Ministry of Agriculture that began in 1890; and a project initiated in 1900 that foresaw the irrigation of 45,000 *desyatin*s.[1152] Prince Massalskiy established a small experimental farm in 1900, and between 1901 and 1903, the Romanov canal was constructed in the Hungry Steppe.[1153] Nikolay was also interested in grand works such as the diversion of the Amu Darya towards the Caspian, with the involvement of F. P. Morgunenkov, a famous Russian engineer.[1154]

For the industrial activities in Russian cities, cotton was a valuable input. As the American Civil War ceased overseas cotton trade, Russian industry imported cotton

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1148 A. Shakhnazarov, *Selskoye Khozyaistvo v Turkestanskom Krai* (St. Petersburg, 1908), p.106.

1149 Lyman Wilbur, "Surveying through Khoresm: A Journey into Parts of Asiatic Russia Which Have Been Closed to Western Travelers Since the World War," *National Geographic Magazine*, June 1932, p.766.

1150 The labor cost by the beginning of the twentieth century was 40-50 kopecks. See: A. Shakhnazarov, *Selskoye Khozyaistvo v Turkestanskom Krai* (St. Petersburg, 1908), pp.102-04.

1151 Ian Matley, "The Golodnaya Steppe: A Russian Irrigation Venture in Central Asia," *Geographical Review*, vol. 60, no. 3, 1970, pp.333-34. Shakhnazarov gives the dates of construction as 1893-1897. See: A. Shakhnazarov, *Selskoye Khozyaistvo v Turkestanskom Krai* (St. Petersburg, 1908), p.105.

1152 A. Shakhnazarov, *Selskoye Khozyaistvo v Turkestanskom Krai* (St. Petersburg, 1908), p.107.

1153 Ian Matley, "The Golodnaya Steppe: A Russian Irrigation Venture in Central Asia," *Geographical Review*, vol. 60, no. 3, 1970, p.336.

1154 Igor Zonn, "Karakum Canal: Artificial River in a Desert," in I.S. Zonn & A.G. Kostianoy, eds. *The Turkmen Lake Altyn Asyr and Water Resources in Turkmenistan*, 2014, p.98. Some claim that the Russian and Soviet experimental hydraulic works in Central Asia were mostly unsuccessful. See: Jeff Sahadeo, *Russian Colonial Society in Tashkent 1865-1923* (Bloomington: Indiana University Press, 2007), p.88.

from Turkestan instead of America,[1155] which increased cotton cultivation in Central Asia.[1156] After a short while, Russians began introducing the American cotton at experimental stations in the late nineteenth century near Tashkent,[1157] and by the beginning of the twentieth century, the Turkestan native cotton began disappearing.[1158] By the beginning of the twentieth century, Turkestan was a global cotton producer. It was the sixth greatest cotton producer globally, following the US, Egypt, China, India, and Japan.[1159]

Agriculture and irrigation in Central Asia were influenced by some crises in the Russian history.[1160] Some irrigation canals were destroyed during the Civil War. As a consequence of the 1917-1918 famine, cotton farming was abandoned for grain

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[1155] During the American Civil War, in 1864, the price of cotton in Moscow increased to 22 to 23 rubles per *pud*s. See: Kn. Massalskiy, *Khlopkovoye Delo v Srednei Azii i Ego Buduschee* (S.Peterburg: B. Kirschbaum, 1892), pp.15-17. The native Turkestan cotton had a "greyish" color and short, woolly fiber. See: Ian Matley, "The Golodnaya Steppe: A Russian Irrigation Venture in Central Asia," *Geographical Review*, vol. 60, no. 3, 1970, p.329. Massalskiy was one of the last observers from the imperial Russia who described Central Asia and studied cotton production. He reports that the Turkestan cotton was of low quality because of short, rigid, and fragile fibers. See: Kn. Massalskiy, *Khlopkovoye Delo v Srednei Azii i Ego Buduschee* (S.Peterburg: B. Kirschbaum, 1892), p.15. See also: Seymour Becker, *Russia's Protectorates in Central Asia: Bukhara and Khiva, 1865-1924* (Cambridge: Harvard University Press, 1968), p.168.

[1156] Excluding the protectorates of Khiva and Bukhara. See: John Whitman, "Turkestan Cotton in Imperial Russia," *American Slavic and East European Review*, vol. 15, no. 2, 1956, p.194.

[1157] This was the first plantation of American cotton in Turkestan. The cotton was purified with American-style gins and sent to the European Russia. See: A. Shakhnazarov, *Selskoye Khozyaistvo v Turkestanskom Krai* (St. Petersburg, 1908), p.143.

[1158] John Whitman, "Turkestan Cotton in Imperial Russia," *American Slavic and East European Review*, vol. 15, no. 2, 1956, p.194. See, for some examples from the literature on Russia-Turkestan cotton trade: A. Shakhnazarov, *Selskoye Khozyaistvo v Turkestanskom Krai* (St. Petersburg, 1908), p.144; Leslie Dienes, "Pasturalism in Turkestan: Its Decline and Its Persistence," *Soviet Studies*, vol. 27, no. 3, 1975, p.350; Beatrice Penati, "The Karp Commission in Context, How the Soviets Discovered Rural Central Asia," *Monde(s)*, vol. 2, no. 4, 2013, p.761; Igor Lipovsky, "The Central Asian Cotton Epic," *Central Asian Survey*, vol. 14, no. 4, 1995, pp.529-30; Mary Holdsworth, "Soviet Central Asia, 1917-1940," *Soviet Studies*, vol. 3, no. 3, 1952, p.259.

[1159] For some detailed statistics on cotton production and trade in Central Asia, see: A. Shakhnazarov, *Selskoye Khozyaistvo v Turkestanskom Krai* (St. Petersburg, 1908), p.154.

[1160] Louis Michael, *Cotton Growing in the Soviet Union*, Bureau of Agricultural Economics, Danube Basin District, 1938, p.2.

farming.[1161] During the Great War and the consecutive Civil War, the price of Turkestan cotton increased dramatically due to its reduced supply.[1162] The reconstruction of the cotton industry after the wars would take almost a decade.[1163]

Table 6-2. Exports of American variety Turkestan cotton to Russia[1164]

Year	Million puds	Metric tonnes
1888	0.873	14,301
1889	1.471	24,087
1890	2.673	43,788
1891	2.626	43,016
1892	3.027	49,574
1893	3.445	56,434
1894	3.759	61,573

6.3.2. The Soviet legacy

Russian advance into Central Asia is seen by some as a period of the introduction of an early modernism,[1165] which peaked during the Soviet era.[1166] Some ambitious

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1161 Ian Matley, "The Golodnaya Steppe: A Russian Irrigation Venture in Central Asia," *Geographical Review*, vol. 60, no. 3, 1970, p.337.

1162 Igor Lipovsky, "The Central Asian Cotton Epic," *Central Asian Survey*, vol. 14, no. 4, 1995, p.533.

1163 Louis Michael, *Cotton Growing in the Soviet Union*, Bureau of Agricultural Economics, Danube Basin District, 1938, p.2.

1164 A. Shakhnazarov, *Selskoye Khozyaistvo v Turkestanskom Krai* (St. Petersburg, 1908), p.143.

1165 See: Christian Teichmann, "Canals, cotton, and the limits of de-colonization in Soviet Uzbekistan, 1924-1941," *Central Asian Survey*, vol. 26, no. 4, 2007, pp.499-501; Maya Peterson, *Technologies of Rule: Empire, Water, and the Modernization of Central Asia, 1867-1941*, Harvard University, 2011, pp.20-24.

1166 Stephen Brain, "The Great Stalin Plan for the Transformation of Nature," *Environmental History*, 2010, pp.1-31. Some authors paid attention to the continuation of the tsarist environmental projects in the Soviet era. See, for example: Paul Josephson et al., *An Environmental History of* projects in Central Asia remained incomplete and contributed to contemporary political and environmental problems.[1167] According to some, water management during the Soviet era was designed for cotton production, and the Soviet government deliberately created water-rich and water-deficit states as an aspect of its nationalities policy.[1168] Abdolvand et al. claim that the water-energy disagreement in the region originates from the Soviet-era institutions not designed for independent states.[1169] On the other hand, a number of scholars agree upon the view that water management during the Soviet era had an integrated, efficient, and cooperative character.[1170]

In the first five-year plan (1928-1932) period, the government aimed at increasing cotton harvest in Central Asia. The target set for self-sufficiency in cotton production was mostly achieved by 1933.[1171] For the initial development of irrigation in Central Asia, Georgii Rizenkampf (1886-1943) was commissioned, who previously

Russia (Cambridge: Cambridge University Press, 2013), p.123; Sarah O'Hara & Tim Hannan, "Irrigation and Water Management in Turkmenistan: Past Systems, Present Problems and Future Scenarios," *Europe-Asia Studies*, vol. 511, 1999, p.25. This latter study regards the continuity as a longer trend extending from the pre-tsarist through the post-Soviet era.

1167 For a discussion on the high-modernism as a worldwide and interconnected trend, see: James Scott, *Seeing Like A State: How Certain Schemes to Improve the Human Condition Have Failed* (New Haven: Yale University Press, 1998), p.193.

1168 Sarah O'Hara, "Central Asia's water resources: contemporary and future management issues," *International Journal of Water Resources Development*, vol. 16, no. 3, 2000, pp.438-39.

1169 Behrooz Abdolvand et al., "The dimension of water in Central Asia: security concerns and the long road of capacity building," *Environmental Earth Sciences*, vol. 73, no. 2, 2015, pp.902-03.

1170 See, for example: Kai Wegerich, "Hydro-hegemony in the Amu Darya Basin," *Water Policy*, vol. 10, no. Supplement 2, 2008; Kai Wegerich, Oliver Olsson & Jochen Froebrich, "Reliving the past in a changed environment: Hydropower ambitions, opportunities and constraints in Tajikistan," *Energy Policy*, vol. 35, no. 7, 2007; Virpi Stucki & Suvi Sojamo, "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*, 2014; Jakob Granit et al., "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*, 2014.

1171 The total demand was 1.87 million bales. See: Louis Michael, *Cotton Growing in the Soviet Union*, Bureau of Agricultural Economics, Danube Basin District, 1938, p.3.

worked on the Hungry Steppe development project in the tsarist era, in 1912,[1172] and he drafted an ambitious program for Central Asia.[1173] The Central Asian water development projects were coordinated by the Central Asian Water Administration with the center in Tashkent. The Administration was able to secure large shares of funds from the central government,[1174] but the initial investments from the Bolshevik government into Central Asian irrigation ventures remained below the level of the tsarist era during the 1920s.[1175] Despite this, with the participation of thousands of laborers, major irrigation canals, such as the 270-kilometer-long Big Fergana Canal, were completed.[1176] As a result, the area of cotton cultivation in Central Asia increased from 442 thousand hectares in 1913 to more than 1 million hectares in 1940.[1177] For the irrigated area to be increased even further, tens of reservoirs were built in the region, and the reservoir capacity increased from 0.17 to 49.3 cubic kilometers between 1950 and 1980. By the year 1980, the total irrigated lands reached to 6.92 million hectares.[1178]

1172 Willi Hager, *Hydraulicians in Europe 1800-2000*, 2014), p.1434.

1173 Christian Teichmann, "Canals, cotton, and the limits of de-colonization in Soviet Uzbekistan, 1924-1941," *Central Asian Survey*, vol. 26, no. 4, 2007, p.503.

1174 As of 1925-1926, the Central Asian Water Administration got 11 million rubles, which corresponded 46.4 percent of the total funds dedicated for irrigation developments in the Soviet Union. See: Christian Teichmann, "Canals, cotton, and the limits of de-colonization in Soviet Uzbekistan, 1924-1941," *Central Asian Survey*, vol. 26, no. 4, 2007, p.504.

1175 Iskandar Abdullaev & Shavkat Rakhmatullaev, "Transformation of Water Management in Central Asia: From State-Centric, Hydraulic Mission to Socio-Political Control," *Environmental Earth Sciences*, vol. 73, no. 2, 2015, p.856.

1176 Iskandar Abdullaev & Shavkat Rakhmatullaev, "Transformation of Water Management in Central Asia: From State-Centric, Hydraulic Mission to Socio-Political Control," *Environmental Earth Sciences*, vol. 73, no. 2, 2015, p.856.

1177 Max Spoor, *Agricultural Restructuring and Trends in Rural Inequalities in Central Asia: A Socio-Statistical Survey*, Civil Society and Social Movements Programme, 2004, p.6.

1178 Shavkat Rakhmatullaev, et al., "Facts and Perspectives of Water Reservoirs in Central Asia: A Special Focus on Uzbekistan," *Water*, vol. 2, no. 2, 2010, p.310.

According to Lenin,[1179] modernization of an agrarian economy necessitated rapid industrialization fueled by electricity,[1180] and the next step for Central Asia would be a drive for electrification through large dams and HPPs. In the drive for electrification, Lenin's associate was Maximillian Krzhizhanovsky (1872-1959).[1181] As early as February 1920, a commission[1182] headed by him drafted a plan[1183] to develop water resources for hydroelectricity generation and to build a common power grid for the whole country. With regards to Central Asia, the plan intended to build electricity generating facilities and new industrial bases.[1184] These plans for Central Asia were repeated in the five-year plans after 1929.[1185] Despite all the plans, hydropower industry developed relatively late in Central Asia.[1186]

1179 The famous words of Lenin on electrification were "*Kommunizm yest Sovetskaya vlast plyus elektrifikatsiya vsey strany, ibo bez elektrifikatsii podnyat promyshlennost nevozmozhno* [Communism is Soviet power plus the electrification of the whole country, since without electrification industry cannot be developed]." See: Vladimir Lenin, Our Foreign and Domestic Position and Party Tasks (Speech Delivered To The Moscow Gubernia Conference Of The R.C.P.(B.)), 1920 [1965].

1180 Vladimir Steklov, *Electrification in the USSR* (Moscow: Foreign Languages Pub. House, 1965), p.11.

1181 Letter from Lenin to Krzhizhanovsky. See: Vladimir Lenin, V.I. Lenin to G. M. Krzhizhanovsky, 1920 [1965], pp.435-36. Lenin read the article of Krzhizhanovsky and started a correspondence with him. For the article, see: Maximillian Krzhizhanovsky, "Zadachi Elektrifikatsii Promyshlennosti," *Pravda*, 30 January 1920.

1182 *Gosudaarstvennaya elektrifikatsiya Rossii* (The State [Commission for the] Electrification of Russia, *GOELRO*, in short).

1183 Emphasis original. Vladimir Steklov, *Electrification in the USSR* (Moscow: Foreign Languages Pub. House, 1965), p.7.

1184 Emphasis added. Vladimir Steklov, *Electrification in the USSR* (Moscow: Foreign Languages Pub. House, 1965), p.19; David Kromm, "Soviet Planning for Increases in Electric Power Production and Capacity," *Transactions of the Kansas Academy of Science (1903-)*, vol. 73, no. 3, 1970, p.283.

1185 See, for details of the plans on electric production: David Kromm, "Soviet Planning for Increases in Electric Power Production and Capacity," *Transactions of the Kansas Academy of Science (1903-)*, vol. 73, no. 3, 1970, pp.285-89.

1186 E. Krylov, "Hydropower Engineering of Prerevolution Russia (History of Hydraulic Engineering)," *Gidrotekhnicheskoe Stroitelstvo* (10), 1976, p.1038. See, the list of the dams in

Before Second World War, some small HPPs were constructed in Central Asia, such as the Varzob cascade that went online in 1936-1937. The level of electricity use in the region was significantly lower than the European part of the Soviet Union in the 1930s as the share of electricity consumed in Central Asia was 9 percent of the total generation by 1937. Prioritized were the strategic agricultural zones around Tashkent and Fergana Valley.[1187]

While under the Khrushchev government some significant projects of Stalin were discredited and suspended,[1188] some hydropower projects in Central Asia remained as exceptions to this general trend. The building of the Toktogul reservoir in Kyrgyzstan, or the construction of the Nurek Dam are some examples.[1189] These large reservoirs were planned to serve both agricultural and electricity generation purposes. The water in the reservoirs were released in the summer to meet the irrigation demand in Uzbekistan. In the winter, while the dams gathered water, the HPPs produce less electricity and the supply gap in the system is compensated by the TPPs in Uzbekistan.[1190] Between the 1970s and the 1990s, hydroelectricity generation in Kyrgyz SSR increased 6.5 times, and more than 84 percent between 1980 and

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Central Asia at: Food and Agriculture Organization of the United Nations, *Aral Sea Basin*, 2012, available at: http://www.fao.org/nr/water/aquastat/basins/aral-sea/aral.sea-CP_eng.pdf (accessed 21 March 2017).

[1187] Eric Thiel, "The Power Industry in the Soviet Union," *Economic Geography*, vol. 27, no. 2, 1951, p.118.

[1188] See: Vladimir Steklov, *Electrification in the USSR* (Moscow: Foreign Languages Pub. House, 1965).

[1189] Paul Josephson et al., *An Environmental History of Russia* (Cambridge: Cambridge University Press, 2013), p.166.

[1190] Shavkat Rakhmatullaev, Iskandar Abdullaev & Jusipbek Kazbekov, "Water-Energy-Food-Environmental Nexus in Central Asia: From Transition to Transformation," in D. Barceló & A.G. Kostianoy, eds. *The Handbook of Environmental Chemistry*, 2017, p.7.

1990.[1191] The basic principle regarding HPPs in the Soviet Union was that the HPPs owned the dams and reservoirs as monopolies.[1192]

In the 1970s, environmental concerns increased in the Soviet Union in parallel to the global trend.[1193] The virgin lands project that involved large parts from Central Asia was criticized both on financial and economic terms.[1194] Still, in Central Asia, investments in large irrigation projects continued until the late Soviet era, and between 1950 and 1988, the total irrigated lands grew up to nearly 70 percent in four Central Asian republics and in the south of Kazakhstan.[1195] In the 2000s, the total land surface under irrigation was 7.85 million hectares. About 78 percent of the Syr Darya and about 94 percent of Amu Darya flow are regulated by the reservoirs.[1196]

1191 Zh. T. Tuleberdiev, K. R. Rakhimov, and Yu. P. Belyakov, *Razvitie energetiki Kyrgyzstana*, Bishkek: Sham, 1997 (Cited in David Gullette & Jeanne Féaux de la Croix, "Mr Light and people's everyday energy struggles in Central Asia and the Caucasus: an introduction," *Central Asian Survey*, vol. 33, no. 4, 2014, p.438.

1192 Irving Fox & O. Kolbasov, *Water resources law and policy in the Soviet Union. Madison: Published for the Water Resources Center* (Wisconsin: University of Wisconsin Press, 1971), p.167.

1193 See, for an example, the citation from *Selskaya Zhizn* (14 July 1970), p. 3 by John Kramer, "Prices and the Conservation of Natural Resources in the Soviet Union," *Soviet Studies*, vol. 24, no. 3, 1973, p.367.

1194 Paul Josephson et al., *An Environmental History of Russia* (Cambridge: Cambridge University Press, 2013), p.169.

1195 Peter Craumer, "Agricultural Change, Labor Supply, and Rural Out-Migration in Soviet Central Asia," in R.A. Lewis, R.R. Churchill & A. Tate, eds. *Geographic Perspectives on Soviet Central Asia*, 1992, pp.132-33. For an account of Soviet era environmental policies from economic, historical, political, ideological, and aesthetic aspects, see: Bernd Richter, "Nature Mastered by Man: Ideology and Water in the Soviet Union," *Environment and History*, vol. 3, no. 1, 1997.

1196 Shavkat Rakhmatullaev, et al., "Facts and Perspectives of Water Reservoirs in Central Asia: A Special Focus on Uzbekistan," *Water*, vol. 2, no. 2, 2010, p.310 and 315.

Some authors stress the trends of continuity and change in water and agriculture sectors in Central Asia.[1197] Arsel and Spoor see, on the other hand, some comprehensive changes[1198] with reference to the history of water management in Central Asia. One may find characteristics of change and continuity in agricultural processes and policies.[1199] Among the major changes was the partial transfer of the ownership of irrigation infrastructure to the water users' associations, most of which were founded in the 2000s,[1200] and to the water management organizations under state control[1201] as a part of the agrarian reform in Uzbekistan.[1202] Among the instances of continuity, in the upstream countries of both the Amu Darya and the Syr Darya basins, several large dam projects were proposed or resurfaced, including

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[1197] Christine Bichsel et al., "Natural Resource Institutions in Transformation: The Tragedy and Glory of the Private," in H. Hurni & U. Wiesmann, eds. *Global Change and Sustainable Development: A Synthesis of Regional Experiences from Research Partnerships*, 2010.

[1198] Murat Arsel & Max Spoor, "Follow the Water," in M. Arsel & M. Spoor, eds. *Water, environmental security and sustainable rural development: conflict and cooperation in Central Eurasia*, 2010, p.11.

[1199] Geert Veldwisch, "Cotton, Rice & Water: The Transformation of Agrarian Relations, Irrigation Technology and Water Distribution in Khorezm, Uzbekistan" 2008, available at: http://d-nb.info/993856918/34, p.18.

[1200] Water users' associations are "self-managing group[s] of farmers working together to operate and maintain their irrigation and drainage network (only inter-farm or on-farm levels) in order to ensure fair and equitable water distribution and increase crop yields." See: Iskandar Abdullaev & Shavkat Rakhmatullaev, "Transformation of Water Management in Central Asia: From State-Centric, Hydraulic Mission to Socio-Political Control," *Environmental Earth Sciences*, vol. 73, no. 2, 2015, pp.858-59.

[1201] Iskandar Abdullaev, *The Socio-Technical Aspects of Water Resources Management in Central Asia* (Saarbrücken: LAP Lambert, 2012), p.29. For an account of the water users' associations in Uzbekistan, see: Darya Zavgorodnyaya, *Water Users Associations in Uzbekistan: Theory and Practice* (Göttingen: Cuvillier Verlag, 2006).

[1202] Gert Veldwisch & Max Spoor, "Contesting Rural Resources: Emerging 'Forms' of Agrarian Production in Uzbekistan," *The Journal of Peasant Studies*, vol. 35, no. 3, 2008; Gert Veldwisch & Peter Mollinga, "Lost in Transition? The Introduction of Water Users Associations in Uzbekistan," *Water International*, vol. 38, no. 6, 2013.

the disputed Rogun[1203] or the Kambarata 1 and 2 projects. The construction of Kambarata-2 is now completed, but the HPP will be fully operational after the completion of the huge Kambarata-1 project, which was initially proposed during the Soviet era but postponed because of the collapse of the Soviet Union. It is still under construction and depends on foreign financing, primarily from Russia, of about 3-6 billion US dollars in total. Upon finishing, Kambarata-1 HPP is planned to be the prevalent electricity producer in the basin with a capacity of 1,900 megawatts.[1204]

After the dissolution of the Soviet Union, water management problems emerged among the Central Asian states. The 1992 Almaty agreement on water sharing could not be implemented. One of the weakest aspects of this agreement was that there were no clear definitions of transboundary water and barter processes in it. Kyrgyz government changed the water release policy from the Toktogul reservoir in order to meet electricity demand in the winter. The summer releases were reduced to 45 percent from 75 percent, while winter releases increased to 55 percent in the 1990s.[1205] The following 1998 Bishkek Agreement tried to be more specific. It foresaw the exchange of hydroelectricity for energy from hydrocarbon resources and described the entire methodology, but it is also failed. The issue of sovereignty became a major problem accelerated by a lack of mutual trust between the Aral Sea

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[1203] Filippo Menga & Naho Mirumachi, "Fostering Tajik Hydraulic Development: Examining the Role of Soft Power in the Case of the Rogun Dam," *Water Alternatives*, vol. 9, no. 2, 2016, p.376.

[1204] Rivers Network, "Naryn river (Syr Darya) : Watersheds map," 2015, available at: http://www.riversnetwork.org/rbo/index.php/river-blogs/central-asia/item/3983 (accessed 19 November 2015).

[1205] Lars Klaus Abbink & Sarah O'Hara, *The Syr Darya River Conflict: An Experimental Case Study*, Centre for Decision Research and Experimental Economics, 2005, available at: https://ideas.repec.org/p/cdx/dpaper/2005-14.html (accessed 5 January 2018), p.4.

basin countries.[1206] These agreements were not recognized by the national assemblies of the republics and thus their international validity is questionable.[1207]

6.3.3. Agriculture and regional water issues

The political dissolution of the Soviet Union led to a complete disintegration in energy and water sectors in Central Asia.[1208] Since the early 1990s, the possibility of a reintegration in the region is widely discussed in the literature,[1209] and one of the main dilemmas here is the conflict between agricultural and hydropower use of the transboundary waters, and the political mismanagement of relevant issues.[1210] Thus far, the involvement of external actors on numerous occasions into the hydro-political issues in the region could not facilitate a solution of complex water management issues.[1211]

[1206] Behrooz Abdolvand et al., "The dimension of water in Central Asia: security concerns and the long road of capacity building," *Environmental Earth Sciences*, vol. 73, no. 2, 2015; Lars Klaus Abbink & Sarah O'Hara, *The Syr Darya River Conflict: An Experimental Case Study*, Centre for Decision Research and Experimental Economics, 2005, available at: https://ideas.repec.org/p/cdx/dpaper/2005-14.html (accessed 5 January 2018), p.5.

[1207] Max Spoor & Anatoly Krutov, "The 'power of water' in a divided Central Asia," *Perspectives on Global Development and Technology*, vol. 2, no. 3/4, 2003, p.607.

[1208] Shavkat Rakhmatullaev, Iskandar Abdullaev & Jusipbek Kazbekov, "Water-Energy-Food-Environmental Nexus in Central Asia: From Transition to Transformation," in D. Barceló & A.G. Kostianoy, eds. *The Handbook of Environmental Chemistry*, 2017, p.7; Aibek Zhupankhan, Kamshat Tussupova & Ronny Berndtsson, "Could Changing Power Relationships Lead to Better Water Sharing in Central Asia?," *Water*, vol. 9, no. 2, 2017, p.2.

[1209] See: Max Spoor & Anatoly Krutov, "The 'power of water' in a divided Central Asia," *Perspectives on Global Development and Technology*, vol. 2, no. 3/4, 2003, pp.593-614; Kai Wegerich, Oliver Olsson & Jochen Froebrich, "Reliving the past in a changed environment: Hydropower ambitions, opportunities and constraints in Tajikistan," *Energy Policy*, vol. 35, no. 7, 2007, pp.3815-25.

[1210] Kai Wegerich, "Hydro-hegemony in the Amu Darya Basin," *Water Policy*, vol. 10, no. Supplement 2, 2008, p.85 and 86.

[1211] Georgi Petrov, "Conflict of interests between hydropower engineering and irrigation in Central Asia: causes and solutions," *Central Asia and the Caucasus*, vol. 11, no. 3, 2010, pp.52-65; Theresa Sabonis-Helf, "The Unified Energy Systems of Russia (RAO-UES) in Central Asia and the Caucasus: nets of interdependence," *Demokratizatsiya*, vol. 15, 2007.

As mentioned above, in the Aral Sea basin, Kyrgyzstan and Tajikistan use water for domestic consumption and electricity generation, while Uzbekistan and Kazakhstan use water primarily for irrigation.[1212] Uzbekistan is the largest consumer of water in the region with 56 cubic kilometers of annual freshwater withdrawals as of 2013 (Figure 6.2), while most of the contribution to the runoff in the Aral Sea basin comes from the upstream Tajikistan and Kyrgyzstan.[1213] In Central Asia, water use characteristics in downstream countries are different from each other. Kazakhstan withdraws 21 cubic kilometers of freshwater annually for agricultural purposes, only 66 percent of its total withdrawal. In the south, Uzbekistan and Turkmenistan have significantly high shares of agricultural water withdrawals (Figure 6.5).[1214] Therefore, a reduction in the total freshwater runoff would lead to losses in downstream agricultural production. Bekchanov and Lamers estimated that a reduction of 10 to 20 percent would lead to a 3.6 to 4.3 percent reduction in Uzbekistan's gross domestic product.[1215]

Some authors argue that the political dominance of Uzbekistan in the Aral Sea basin has been decisive for hydropolitical relations in the region, and conflict and cooperation coexists since the independence.[1216] On the other hand, some authors argue that water and environment are suitable issue areas for regional cooperation. For

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[1212] Bakhtiar Bakas Uulu & Kadyrzhan Smagulov, "Central Asia's hydropower problems: regional states' policy and development prospects," *Central Asia and the Caucasus*, vol. 12, no. 1, 2011, p.81; Shavkat Rakhmatullaev, Iskandar Abdullaev & Jusipbek Kazbekov, "Water-Energy-Food-Environmental Nexus in Central Asia: From Transition to Transformation," in D. Barceló & A.G. Kostianoy, eds. *The Handbook of Environmental Chemistry*, 2017, p.3.

[1213] Aibek Zhupankhan, Kamshat Tussupova & Ronny Berndtsson, "Could Changing Power Relationships Lead to Better Water Sharing in Central Asia?," *Water*, vol. 9, no. 2, 2017, p.2.

[1214] World Bank, "World Development Indicators," *The World Bank Databank*, 2017, available at: http://data.worldbank.org (accessed 31 January 2017).

[1215] Maksud Bekchanov & John Lamers, "Economic costs of reduced irrigation water availability in Uzbekistan (Central Asia)," *Regional Environmental Change*, vol. 16, no. 8, 2016.

[1216] Suvi Sojamo, "Illustrating co-existing conflict and cooperation in the Aral Sea Basin with TWINS approach," in M.M. Rahaman & O. Varis, eds. *Central Asian Waters: Social, economic, environmental and governance puzzle*, 2008, p.79.

instance, Pak and Wegerich focus on the cooperation potential, particularly in small-scale transboundary reservoirs. One example for such a cooperation is the Andijan Reservoir that is managed and upheld jointly by Kyrgyzstan and Uzbekistan.[1217] Mutual trust among the riparians is a necessity for a cooperative water management framework.[1218] Many authors focus on the importance of local water institutions and the need for regional cooperation are emphasized by researchers as well,[1219] particularly from a nexus perspective.[1220] Some scholars propose full implementation of the existing international agreements,[1221] and some suggest development of new and improvement of existing water reservoirs, irrigation and

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[1217] Mariya Pak & Kai Wegerich, "Competition and benefit sharing in the Ferghana Valley," *Central Asian Affairs*, vol. 1, 2014. See, especially: pp. 239-245.

[1218] Maksud Bekchanov, *Efficient Water Allocation and Water Conservation Policy Modelling in the Aral Sea Basin*, Rheinischen Friedrich-Wilhelms-Universität Bonn, 2013, available at: http://hss.ulb.uni-bonn.de/2014/3609/3609.pdf (accessed 15 November 2015).

[1219] See, for further discussions on this topic: Lars Klaus Abbink & Sarah O'Hara, *The Syr Darya River Conflict: An Experimental Case Study*, Centre for Decision Research and Experimental Economics, 2005, available at: https://ideas.repec.org/p/cdx/dpaper/2005-14.html (accessed 5 January 2018); Jakob Granit et al., *Regional Water Intelligence Report Central Asia*, 2010, available at: http://watergovernance.org/resources/regional-water-intelligence-report-central-asia/ (accessed 24 November 2015); Joelle Rizk & Berdakh Utemuratov, *Balancing the Use of Water Resources in the Amu Darya Basin*, 2012, available at: http://amudaryabasin.net/resources/balancing-use-water-resources-amu-darya-basin (accessed 21 November 2015); Eurasian Development Bank, *Water and Energy Resources in Central Asia: Utilization and Development Issues*, 2008, available at: http://eabr.org/general/upload/docs/Report_2_water_and_energy_EDB.pdf (accessed 24 November 2015); Bakhtiar Bakas Uulu & Kadyrzhan Smagulov, "Central Asia's hydropower problems: regional states' policy and development prospects," *Central Asia and the Caucasus*, vol. 12, no. 1, 2011; Ilkhom Soliev, Kai Wegerich & Jusipbek Kazbekov, "The Costs of Benefit Sharing: Historical and Institutional Analysis of Shared Water Development in the Ferghana Valley, the Syr Darya Basin," *Water*, vol. 7, no. 6, 2015.

[1220] Iskandar Abdullaev & Shavkat Rakhmatullaev, "Setting up the Agenda for Water Reforms in Central Asia: Does the Nexus Approach Help?," *Environmental Earth Sciences*, vol. 75, no. 10, 2016; Shokhrukh-Mirzo Jalilov, et al., "Managing the Water-Energy-Food Nexus: Gains and Losses from New Water Development in Amu Darya River Basin," *Journal of Hydrology*, vol. 539, 2016; Marko Keskinen et al., "The Water-Energy-Food Nexus and the Transboundary Context: Insights from Large Asian Rivers," *Water*, vol. 8, no. 5, 2016.

[1221] Georgi Petrov, "Conflict of interests between hydropower engineering and irrigation in Central Asia: causes and solutions," *Central Asia and the Caucasus*, vol. 11, no. 3, 2010.

interconnection systems, both within Central Asia,[1222] as well as those systems between Central Asian countries and their neighbors such as China, Afghanistan, or Pakistan.[1223]

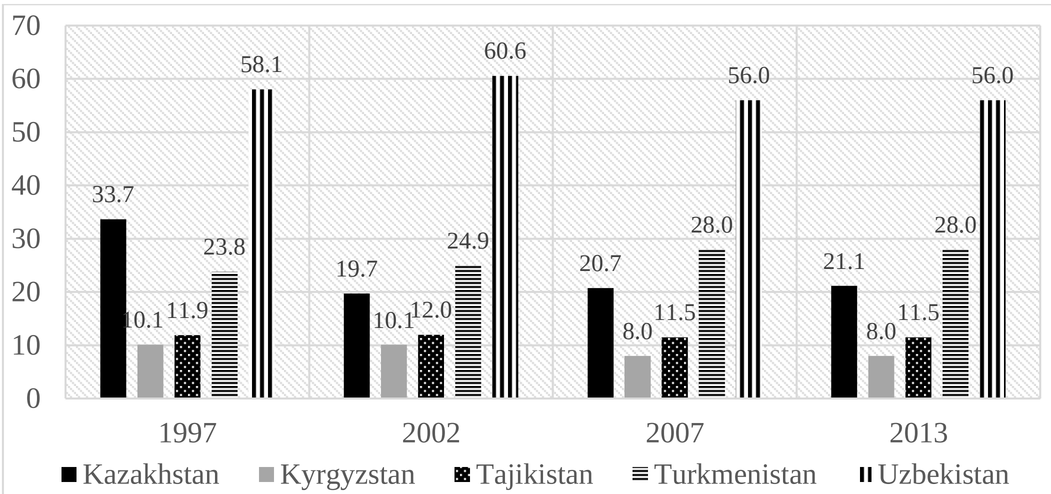

Figure 6.2. Total water withdrawals in the Aral Sea basin, cubic kilometers

Irrigation is the key for agricultural activity in the Aral Sea basin. According to estimates, about 8 million hectares of land in the Aral Sea basin are under irrigation.[1224] There are severe problems in the irrigation systems in both the Amu Darya and Syr Darya basins, and this causes economic losses. The use of irrigation canals, most of which were built during the Soviet era, degraded and needs severe efforts

[1222] Maksud Bekchanov, *Efficient Water Allocation and Water Conservation Policy Modelling in the Aral Sea Basin*, Rheinischen Friedrich-Wilhelms-Universität Bonn, 2013, available at: http://hss.ulb.uni-bonn.de/2014/3609/3609.pdf (accessed 15 November 2015).

[1223] Bakhtiar Bakas Uulu & Kadyrzhan Smagulov, "Central Asia's hydropower problems: regional states' policy and development prospects," *Central Asia and the Caucasus*, vol. 12, no. 1, 2011.

[1224] Iskandar Abdullaev, *The Socio-Technical Aspects of Water Resources Management in Central Asia* (Saarbrücken: LAP Lambert, 2012), p.2.

for maintenance. The water leakage in the unlined canals is high,[1225] and the estimates of international organizations estimate that annually about 0.7 and 1 billion US dollars in the Syr Darya and Amu Darya basins, respectively, are wasted due to water scarcity, drainage, and salinization problems. More than 50 percent these agricultural losses take place in Uzbekistan. Also, water transportation through canals are responsible for fifty to sixty percent of water loss.[1226] Large scale agriculture is applied in the plains and fertile valleys, particularly in Uzbekistan, Turkmenistan, and Kazakhstan. The mountainous Kyrgyzstan and Tajikistan have relatively smaller lands suitable for agricultural production. Of Kyrgyzstan's 200 thousand square kilometers land surface, 13.5 thousand square kilometers are cultivated as of 2009.[1227] On the other hand, Uzbekistan's agricultural lands are 46.5 thousand square kilometers as of 2009, while the cultivable area is much wider, estimated at 254 thousand square kilometers, wider than Kyrgyzstan's total land surface.[1228]

[1225] Max Spoor & Anatoly Krutov, "The 'power of water' in a divided Central Asia," *Perspectives on Global Development and Technology*, vol. 2, no. 3/4, 2003, p.597.

[1226] Joelle Rizk & Berdakh Utemuratov, *Balancing the Use of Water Resources in the Amu Darya Basin*, 2012, available at: http://amudaryabasin.net/resources/balancing-use-water-resources-amu-darya-basin (accessed 21 November 2015), p.7; Joseph Guillaume, Matti Kummu, Stephanie Eisner & Olli Varis, "Transferable Principles for Managing the Nexus: Lessons from Historical Global Water Modelling of Central Asia," *Water*, vol. 7, no. 8, 2015, p.4210; Shavkat Rakhmatullaev, et al., "Facts and Perspectives of Water Reservoirs in Central Asia: A Special Focus on Uzbekistan," *Water*, vol. 2, no. 2, 2010, p.308.

[1227] Food and Agriculture Organization of the United Nations, "Kyrgyzstan," *Aquastat*, 2016, available at: http://www.fao.org/nr/water/aquastat/countries_regions/KGZ/ (accessed 12 September 2017).

[1228] Food and Agriculture Organization of the United Nations, "Uzbekistan," *Aquastat*, 2016, available at: http://www.fao.org/nr/water/aquastat/countries_regions/UZB/ (accessed 13 September 2017)

The main agricultural produce and export commodity of Uzbekistan is cotton,[1229] along with wheat, fruits, vegetables, melons, and potato.[1230] Cotton and wheat are seen as strategic products and are under state control, and commercial production is possible only after meeting state quotas.[1231] The lower part of the Naryn basin opens up to Fergana Valley, where irrigated agriculture is of crucial importance, mainly because of cotton production (Figure 6.3).[1232] On the other hand, the share of irrigated land per capita in the whole Central Asia has been declining since 1960, from the level of 0.32 hectares to 0.19 hectares (as of 2000) with the impact of population growth,[1233] and due to changing economic conditions and agriculture policies in principal agricultural economies since the mid-2000s, especially in

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[1229] Uzbekistan exported nearly 1 billion US dollars-worth pure cotton and non-retail pure cotton yarn in 2013, corresponding to 48 percent of its total agricultural exports (including animal products). See: A.J.G. Simoes & C.A. Hidalgo, "The Economic Complexity Observatory: An Analytical Tool for Understanding the Dynamics of Economic Development," 2011, available at: http://atlas.media.mit.edu/en/visualize/tree_map/hs92/export/uzb/all/show/2013/ (accessed 28 November 2015). See, for the proceedings of a conference on the cotton sector in Central Asia: Kandiyoti, D., ed., "The Cotton Sector in Central Asia: Economic Policy and Development Challenges," 2007.

[1230] ICARDA, ICARDA in Central Asia and the Caucasus: A Partnership Dedicated to Sustainable Agriculture Development and Food Security, 2013, p.15.

[1231] Gert Veldwisch & Max Spoor, "Contesting Rural Resources: Emerging ‘Forms’ of Agrarian Production in Uzbekistan," *The Journal of Peasant Studies*, vol. 35, no. 3, 2008.

[1232] Food and Agriculture Organization of the United Nations, "Percentage of land irrigated," *Aquastat*, 2013 (5), available at: http://www.fao.org/geonetwork/srv/en/metadata.show?id=5020 (accessed 12 November 2015). The irrigated areas of Uzbekistan in the Fergana Valley, Andijan, Fergana, Namangan, Sirdarya and Tashkent together comprise 38 per cent of the total irrigated land in the country. See: Stefan Siebert, Verena Henrich, Karen Frenken & Jacob Burke, "Global Map of Irrigation Areas version 5. Rheinische Friedrich-Wilhelms-University, Bonn, Germany / Food and Agriculture Organization of the United Nations, Rome, Italy," 2013, available at: http://www.fao.org/nr/water/aquastat/irrigationmap/UZB/index.stm (accessed 16 November 2015).

[1233] Eurasian Development Bank, *Water and Energy Resources in Central Asia: Utilization and Development Issues*, 2008, available at: http://eabr.org/general/upload/docs/Report_2_water_and_energy_EDB.pdf (accessed 24 November 2015), pp.7-8; Shavkat Rakhmatullaev, Iskandar Abdullaev & Jusipbek Kazbekov, "Water-Energy-Food-Environmental Nexus in Central Asia: From Transition to Transformation," in D. Barceló & A.G. Kostianoy, eds. *The Handbook of Environmental Chemistry*, 2017, p.13.

Uzbekistan (Figure 6.4).[1234] Cotton is also cultivated in the southern part of Kyrgyzstan, especially in Osh and Jalal-Abad provinces. Unlike Uzbekistan, cotton cultivation did not decline in these cities after the independence.[1235]

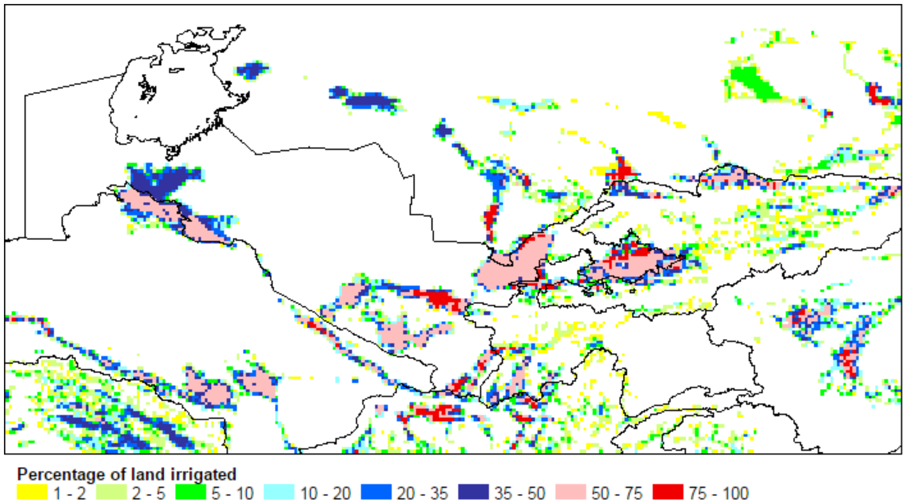

Figure 6.3. Percentage of irrigated land in Central Asia[1236]

[1234] Halil Sakal, "A Quarter-Century Pursuit of Independence: Politics of Trade, Energy, and Economic Development in Uzbekistan," *Perceptions*, vol. 22, no. 1, 2017; Joseph Guillaume, Matti Kummu, Stephanie Eisner & Olli Varis, "Transferable Principles for Managing the Nexus: Lessons from Historical Global Water Modelling of Central Asia," *Water*, vol. 7, no. 8, 2015, p.4211 and 4224; Iskandar Abdullaev & Shavkat Rakhmatullaev, "Setting up the Agenda for Water Reforms in Central Asia: Does the Nexus Approach Help?," *Environmental Earth Sciences*, vol. 75, no. 10, 2016, p.5; V. Nangia, et al., *Evapotranspiration-based Irrigation Scheduling for Cotton Growing in Fergana Valley to Improve Water-use Efficiency*, 2014, available at: http://cac-program.org/download/file/152 (accessed 25 January 2018); Gert Veldwisch & Max Spoor, "Contesting Rural Resources: Emerging 'Forms' of Agrarian Production in Uzbekistan," *The Journal of Peasant Studies*, vol. 35, no. 3, 2008, pp.427-28.

[1235] Alexander Kim, "Abandoned by the State: Cotton Production in South Kazakhstan," in D. Kandiyoti, ed. *The Cotton Sector in Central Asia: Economic Policy and Development Challenges*, 2007, p.119.

[1236] Food and Agriculture Organization of the United Nations, "Percentage of land irrigated," *Aquastat*, 2013 (5), available at: http://www.fao.org/geonetwork/srv/en/metadata.show?id=5020 (accessed 12 November 2015).

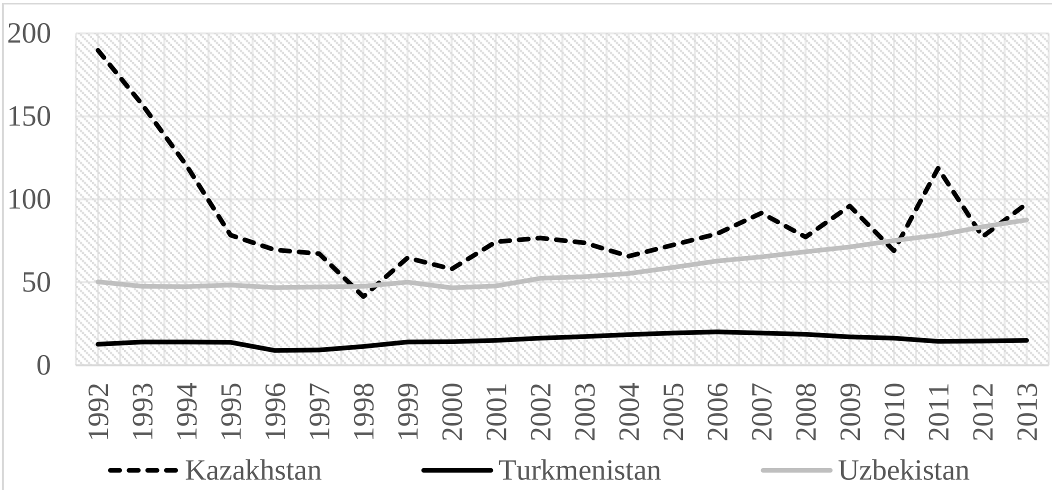

Figure 6.4. Agricultural production in downstream countries, million tons[1237]

The crops cultivated in the Fergana Valley require relatively high amounts of water (Figure 6.5).[1238] Cotton and wheat require 18.4 cubic meters of water per US dollar output, while for fruits and other vegetables, this amount is less than half of it.[1239] For a ton of cotton to be harvested in Uzbekistan, about 4.4 thousand cubic meters of water is needed. For growing wheat, about 2.1 thousand cubic meters of water is consumed.[1240] As a whole, cotton, wheat and rice production are responsible for 86

[1237] FAOSTAT, "Food and Agriculture Organization of United Nations," 2015, available at: http://faostat3.fao.org (accessed 24 November 2015).

[1238] Shavkat Rakhmatullaev, Iskandar Abdullaev & Jusipbek Kazbekov, "Water-Energy-Food-Environmental Nexus in Central Asia: From Transition to Transformation," in D. Barceló & A.G. Kostianoy, eds. *The Handbook of Environmental Chemistry*, 2017, p.3.

[1239] Maksud Bekchanov, *Efficient Water Allocation and Water Conservation Policy Modelling in the Aral Sea Basin*, Rheinischen Friedrich-Wilhelms-Universität Bonn, 2013, available at: http://hss.ulb.uni-bonn.de/2014/3609/3609.pdf (accessed 15 November 2015), pp.190-91.

[1240] Shavkat Rakhmatullaev, Iskandar Abdullaev & Jusipbek Kazbekov, "Water-Energy-Food-Environmental Nexus in Central Asia: From Transition to Transformation," in D. Barceló & A.G. Kostianoy, eds. *The Handbook of Environmental Chemistry*, 2017, p.13.

percent of all blue water consumed in Central Asia.[1241] Under the arid climate of Uzbekistan, cotton production is ineffective as Uzbek cotton requires 999 millimeters of rainwater, but receives only about 19 millimeters, meaning that about 98 percent of water demand must be met from blue water supply.[1242] Because of the reasons mentioned here, fruits and vegetables began to be encouraged in Uzbekistan in recent years.[1243] Despite this high amount of water requirement for agricultural production, Central Asian states are net exporters of agricultural commodities and horticultural products. This means that there is a net virtual water outflow from the region.[1244]

[1241] Miina Porkka, Matti Kummu, Stefan Siebert & Martina Flörke, "The Role of Virtual Water Flows in Physical Water Scarcity: The Case of Central Asia," *International Journal of Water Resources Development*, vol. 28, no. 3, 2012, p.467. For a case study of water productivity of cotton production in Fergana Valley, see: J. Reddy, Shukhrat Muhammedjanov, Kahramon Jumaboev & Davron Eshmuratov, "Analysis of cotton water productivity in Fergana Valley of Central Asia," *Agricultural Sciences*, vol. 3, no. 6, 2012. See also: Olli Varis, "Curb vast water use in central Asia," *Nature*, vol. 514, 2014.

[1242] A. Chapagain, A. Hoekstra, H. Savenije & R. Gautam, *The Water Footprint of Cotton Consumption*, 2005, available at: http://waterfootprint.org/media/downloads/Report18.pdf (accessed 21 November 2015), p.15; Joseph Guillaume, Matti Kummu, Stephanie Eisner & Olli Varis, "Transferable Principles for Managing the Nexus: Lessons from Historical Global Water Modelling of Central Asia," *Water*, vol. 7, no. 8, 2015, pp.4209-10.

[1243] Shavkat Rakhmatullaev, Iskandar Abdullaev & Jusipbek Kazbekov, "Water-Energy-Food-Environmental Nexus in Central Asia: From Transition to Transformation," in D. Barceló & A.G. Kostianoy, eds. *The Handbook of Environmental Chemistry*, 2017, p.13.

[1244] Miina Porkka, Matti Kummu, Stefan Siebert & Martina Flörke, "The Role of Virtual Water Flows in Physical Water Scarcity: The Case of Central Asia," *International Journal of Water Resources Development*, vol. 28, no. 3, 2012.

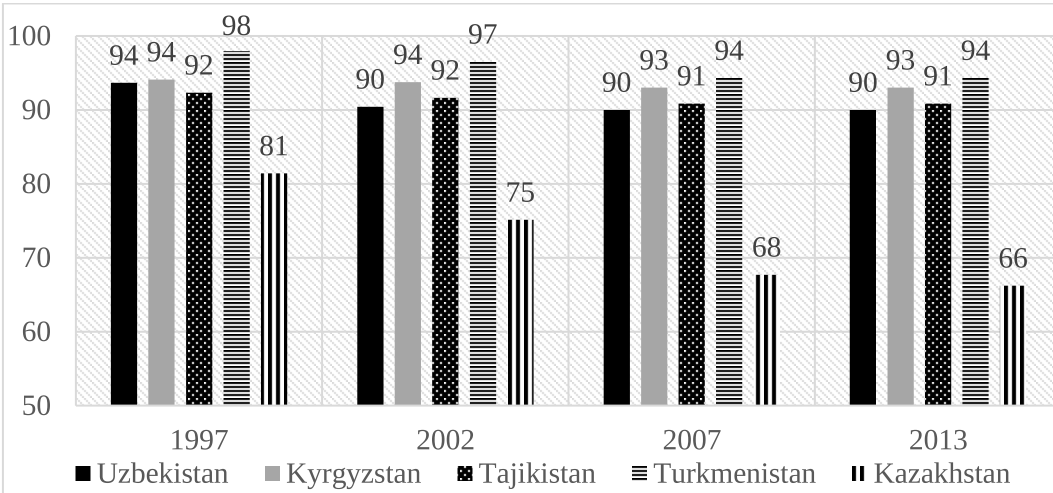

Figure 6.5. Freshwater withdrawals of agriculture (percent of total)[1245]

Like other arid river basins around the world, climate change tends to exacerbate water stress in the Aral Sea basin. According to estimates, by 2050, the amount of freshwater in the grand rivers Amu Darya and Syr Darya will decrease 10 to 30 percent,[1246] and this will result in an increase in irrigation water demand across the region.[1247] The already degraded status of Central Asian environment caused primarily by the Aral Sea crisis is further exacerbated by the impacts of the climate change. Some authors tried to find parallels between the environmental problems

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[1245] World Bank, "World Development Indicators," *The World Bank Databank*, 2017, available at: http://data.worldbank.org (accessed 31 January 2017).

[1246] Shavkat Rakhmatullaev, Iskandar Abdullaev & Jusipbek Kazbekov, "Water-Energy-Food-Environmental Nexus in Central Asia: From Transition to Transformation," in D. Barceló & A.G. Kostianoy, eds. *The Handbook of Environmental Chemistry*, 2017, p.3; Aibek Zhupankhan, Kamshat Tussupova & Ronny Berndtsson, "Could Changing Power Relationships Lead to Better Water Sharing in Central Asia?," *Water*, vol. 9, no. 2, 2017, p.10; Shavkat Rakhmatullaev, et al., "Facts and Perspectives of Water Reservoirs in Central Asia: A Special Focus on Uzbekistan," *Water*, vol. 2, no. 2, 2010, p.308.

[1247] Iskandar Abdullaev & Shavkat Rakhmatullaev, "Setting up the Agenda for Water Reforms in Central Asia: Does the Nexus Approach Help?," *Environmental Earth Sciences*, vol. 75, no. 10, 2016, p.7. See also: Maksud Bekchanov & John Lamers, "Economic costs of reduced irrigation water availability in Uzbekistan (Central Asia)," *Regional Environmental Change*, vol. 16, no. 8, 2016.

and the political turbulence in Kyrgyzstan during the 2000s.[1248] The reduced amount of freshwater in the rivers means a decrease in hydropower generation for Kyrgyzstan, causing blackouts and catalyzing popular discontent.[1249]

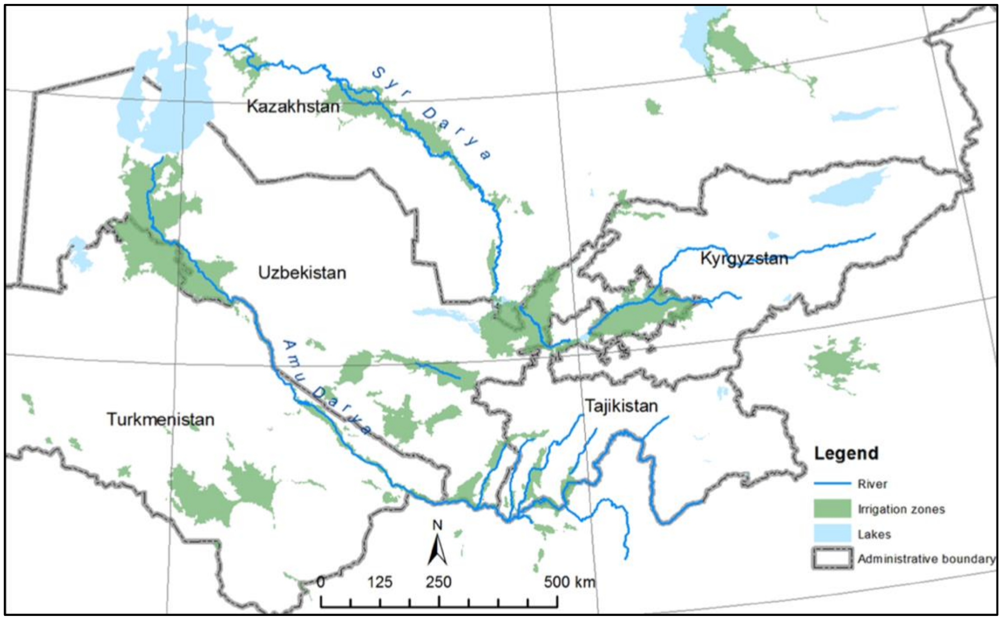

Figure 6.6. Main rivers and irrigation in Central Asia[1250]

In general, water demand in the Aral Sea basin is on critical levels and ineffective use of water exacerbates water stress and the dispute on irrigation and water nexus in the region. The involvement of hydroelectricity generation into this picture is

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[1248] Amanda Wooden, "Another Way of Saying Enough: Environmental Concern and Popular Mobilization in Kyrgyzstan," *Post-Soviet Affairs*, vol. 29, no. 4, 2013.

[1249] See, for the discussion on the results of a survey conducted in 2009 in Kyrgyzstan about hydroelectricity and environment issues: Amanda Wooden, "Kyrgyzstan's Dark Ages: Framing and the 2010 Hydroelectric Revolution," *Central Asian Survey*, vol. 33, no. 4, 2014.

[1250] Maksud Bekchanov & John Lamers, "Economic costs of reduced irrigation water availability in Uzbekistan (Central Asia)," *Regional Environmental Change*, vol. 16, no. 8, 2016, p.2371.

crucial and should be paid particular attention, which is the main aim of the following section.

6.4. Electricity and interconnections

Kyrgyzstan and Tajikistan lack hydrocarbon resources and need water for electricity generation.[1251] There is a high and underexploited potential in these upstream riparians and this is the main source of the hydropolitical dispute. As Kyrgyzstan needs energy and electricity[1252] for internal use and for generating revenues by exporting it, the weight of agriculture in the downstream countries complicates the situation and increases political pressure on Kyrgyz water development projects.

6.4.1. Economy and electricity production

On the Naryn River, a cascade of five main HPPs were installed by Kyrgyzstan, downstream of the Toktogul Reservoir (Figure 6.7). The Toktogul HPP is 215 meters tall and has a 1,200 megawatts of installed capacity. The other HPPs are smaller. The Kurpsai has 800, while the Tashkömür 450, the Shamaldy Say 240, and the Uch-Kurgan 180 megawatts of installed capacity. These dams date back to Soviet era and were constructed between 1962 and 1987,[1253] which is an indicator for the fact that the electricity production and transmission infrastructure of Kyrgyzstan needs immediate maintenance and improvements.

[1251] See: James Dorian, "Central Asia: A major emerging energy player in the 21st century☆," *Energy Policy*, vol. 34, no. 5, 2006.

[1252] Despite its high hydropower potential, Kyrgyzstan is a net electricity importer. See: Eurasian Development Bank, *Water and Energy Resources in Central Asia: Utilization and Development Issues*, 2008, available at: http://eabr.org/general/upload/docs/Report_2_water_and_energy_EDB.pdf (accessed 24 November 2015), p.10.

[1253] Global Energy Observatory, 2015, available at: http://www.globalenergyobservatory.org/constructNetworkIndex.php (accessed 15 November 2015).

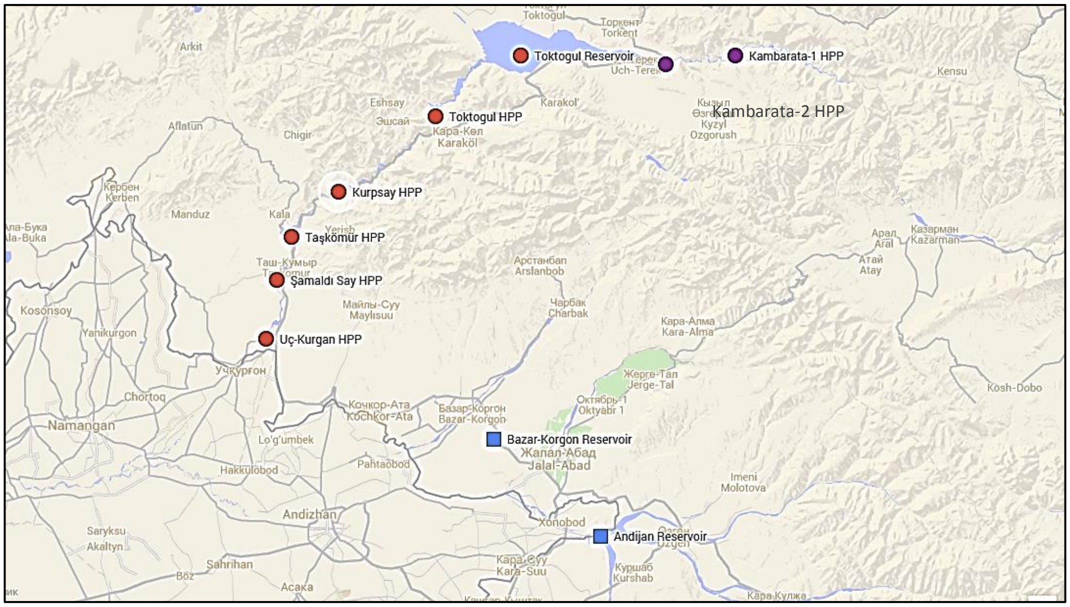

Figure 6.7. HPPs and reservoirs on the Naryn River in Kyrgyzstan[1254]

Still, the upstream of the Aral Sea basin has an underexploited hydropower potential. Tajikistan developed 5 percent of its estimated potential, while in Kyrgyzstan, this share is about 10 to 14 percent of th 99 TWh of yearly economically feasible

[1254] Global Energy Observatory, 2015, available at: http://www.globalenergyobservatory.org/constructNetworkIndex.php (accessed 15 November 2015).

potential.[1255] On the Naryn tributary of the Syr Darya alone, an estimated 33 additional HPPs with a total of 6,450 megawatts installed capacity can be built.[1256] Kazakhstan and Uzbekistan are utilizing a higher share of their economic hydropower potential.[1257]

There are some plans for further developing electricity generating capacity in the region. Kazakhstan and Uzbekistan already scheduled to increase thermal power generation capacity, while Kyrgyzstan plans to install new HPPs for generating about 6 TWh of electricity per annum.[1258] On the condition that the HPPs of Kyrgyzstan are finalized, the Kyrgyz authorities may seek to export excess electricity.

Some authors focus on the self-interested power policies in the Central Asian countries.[1259] Just after the independence Kyrgyzstan changed the operation principles of the Toktogul Dam and HPP to power mode. The dams released water in the winter to produce electricity, whose demand rise in winter. In the summer, as a

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[1255] N. Abdyrasulova & N. Kravsov, *Electricity Governance in Kyrgyzstan: An Institutional Assessment*, 2009, available at: http://electricitygovernance.wri.org/files/egi/Kyr_EGI_FINAL_5.6.10.pdf (accessed 15 November 2015), p.5. See: Eurasian Development Bank, *Water and Energy Resources in Central Asia: Utilization and Development Issues*, 2008, available at: http://eabr.org/general/upload/docs/Report_2_water_and_energy_EDB.pdf (accessed 24 November 2015), p.10.

[1256] Jefferson Institute, *Developing the Potential for Energy Efficiency and Alternative Energy in the Kyrgyz Republic*, 2009, available at: http://www.jeffersoninst.org/sites/default/files/Kyrgyz_policy_paper_0_0.pdf, p.6.

[1257] Eurasian Development Bank, *Water and Energy Resources in Central Asia: Utilization and Development Issues*, 2008, available at: http://eabr.org/general/upload/docs/Report_2_water_and_energy_EDB.pdf (accessed 24 November 2015), p.10; Maksud Bekchanov, *Efficient Water Allocation and Water Conservation Policy Modelling in the Aral Sea Basin*, Rheinischen Friedrich-Wilhelms-Universität Bonn, 2013, available at: http://hss.ulb.uni-bonn.de/2014/3609/3609.pdf (accessed 15 November 2015), p.55.

[1258] Siegfried Grunwald, *Central Asia Regional Economic Cooperation: Power Sector Regional Master Plan*, Asian Development Bank, 2012, available at: http://www.adb.org/projects/documents/central-asia-regional-economic-cooperation-power-sector-regional-master-plan-tacr (accessed 17 November 2015).

[1259] Theresa Sabonis-Helf, "The Unified Energy Systems of Russia (RAO-UES) in Central Asia and the Caucasus: nets of interdependence," *Demokratizatsiya*, vol. 15, 2007, pp.430-31.

consequence, there is only limited amount of water remaining in the reservoirs for irrigation purposes.[1260] Despite this, the electricity generation in the Toktogul HPP[1261] does not meet the demand,[1262] a situation which led Kyrgyz authorities seek ways for increasing hydropower generation capacity on the Naryn River cascade. Uzbekistani authorities threatened for ceasing the gas supplies to Kyrgyzstan as retaliation.[1263] Uzbekistan government, particularly Islam Karimov, used to contradict upstream development projects on all occasions.[1264] While some scholars argue that Uzbekistan's opposition to the upstream water development projects[1265]

1260 Shavkat Rakhmatullaev, Iskandar Abdullaev & Jusipbek Kazbekov, "Water-Energy-Food-Environmental Nexus in Central Asia: From Transition to Transformation," in D. Barceló & A.G. Kostianoy, eds. *The Handbook of Environmental Chemistry*, 2017, p.7.

1261 For an anthropological account and detailed description of the Toktogul dam and reservoir, see: Jeanne Féaux de la Croix, "Moving Metaphors We Live By: Water and Flow in the Social Sciences and around Hydroelectric Dams in Kyrgyzstan," *Central Asian Survey*, vol. 30, no. 3-4, 2011.

1262 Lars Klaus Abbink & Sarah O'Hara, *The Syr Darya River Conflict: An Experimental Case Study*, Centre for Decision Research and Experimental Economics, 2005, available at: https://ideas.repec.org/p/cdx/dpaper/2005-14.html (accessed 5 January 2018), p.4.

1263 Suvi Sojamo, "Illustrating co-existing conflict and cooperation in the Aral Sea Basin with TWINS approach," in M.M. Rahaman & O. Varis, eds. *Central Asian Waters: Social, economic, environmental and governance puzzle*, 2008, p.80.

1264 See, for different examples of the statements of Karimov: Avesta.tj, "Sharp Statement of Islam Karimov on Rogun Project," 2012, available at: http://www.avesta.tj/eng/rogun/2900-sharp-statement-of-islam-karimov-on-rogun-project.html (accessed 16 November 2015); " BNE Intellinews, "Uzbek president courts Kazakh leader to improve relations with Russia," 2014, available at: http://www.intellinews.com/uzbek-president-courts-kazakh-leader-to-improve-relations-with-russia-500441701/?source=russia&archive=bne (accessed 16 November 2015); Elmurad Kasym, "Central Asia's Hydropower Spat," *The Diplomat,* 2014, available at: http://thediplomat.com/2014/12/central-asias-hydropower-spat/ (accessed 16 November 2015). Also see: David Gullette & Jeanne Féaux de la Croix, "Mr Light and people's everyday energy struggles in Central Asia and the Caucasus: an introduction," *Central Asian Survey*, vol. 33, no. 4, 2014.

1265 See, for a discussion on the Rogun Dam project in Tajikistan: Kai Wegerich, Oliver Olsson & Jochen Froebrich, "Reliving the past in a changed environment: Hydropower ambitions, opportunities and constraints in Tajikistan," *Energy Policy*, vol. 35, no. 7, 2007; Lea Melnikovová, Bohumil Havrland & Radim Valenčík, "Rogun - Hydropower Generating Controversy in Central Asia," *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis,* vol. 62, no. 6, 2014; Filippo Menga & Naho Mirumachi, "Fostering Tajik Hydraulic Development: Examining the Role of Soft Power in the Case of the Rogun Dam," *Water Alternatives*, vol. 9, no. 2, 2016, p.376; Shokhrukh-Mirzo Jalilov, et al., "Managing the Water-Energy-Food Nexus: Gains and reflected the will of Uzbekistan leadership to impose a political dominance on the upstream neighbors, after Karimov, there have been some promising developments in the region as some of the most significant the political disputes tend to get closer to a resolution through bilateral negotiations.[1266] On the other hand, some suggest an increasing mediating role from Russia in the transboundary river conflicts in the region.[1267]

Despite the concerns of the downstream countries, some upstream projects supported by Russia and other international actors continue.[1268] The Kambarata-2 HPP project was finalized, in cooperation with the Russia-based hydropower company RusHydro.[1269] But before the 1,900 megawatts Kambarata-1 becomes operational, the Kambarata-2 will function below capacity.[1270] Russia plays an economically and politically key role here,[1271] and it seeks some political gains in return for technical and financial support. For the Kambarata deal, Russia has forgiven 500 million US dollars of debt from Kyrgyzstan insisted on military presence in

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Losses from New Water Development in Amu Darya River Basin," *Journal of Hydrology*, vol. 539, 2016.

1266 Shavkat Rakhmatullaev, Iskandar Abdullaev & Jusipbek Kazbekov, "Water-Energy-Food-Environmental Nexus in Central Asia: From Transition to Transformation," in D. Barceló & A.G. Kostianoy, eds. *The Handbook of Environmental Chemistry*, 2017, p.7.

1267 Vladimir Paramonov, Vodno-energeticheskaya problema Tsentralnoy Azii i politika Rossii, n.d..

1268 China View, "Kyrgyzstan to build hydroelectric stations despite opposition," 2009, available at: http://news.xinhuanet.com/english/2009-04/17/content_11200757.htm (accessed 15 November 2015).

1269 Aibek Zhupankhan, Kamshat Tussupova & Ronny Berndtsson, "Could Changing Power Relationships Lead to Better Water Sharing in Central Asia?," *Water*, vol. 9, no. 2, 2017, p.11.

1270 Behrooz Abdolvand et al., "The dimension of water in Central Asia: security concerns and the long road of capacity building," *Environmental Earth Sciences*, vol. 73, no. 2, 2015, p.904.

1271 Eurasian Development Bank, *Water and Energy Resources in Central Asia: Utilization and Development Issues*, 2008, available at: http://eabr.org/general/upload/docs/Report_2_water_and_energy_EDB.pdf (accessed 24 November 2015), p.20.

Kyrgyzstan.[1272] The weight of China has been increasing in Kyrgyzstan's electricity sector as well. In the short-term, Kyrgyzstan is expected to receive about 1.5 billion US dollars-worth investments from China for the building of the Kazarman cascade of HPPs.[1273]

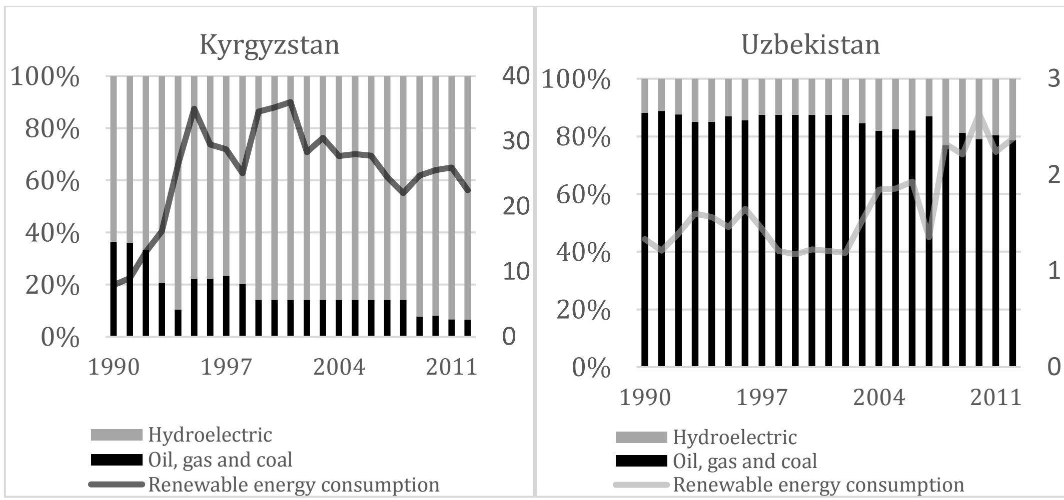

Figure 6.8. Electricity production in Kyrgyzstan and Uzbekistan (share of total)[1274]

[1272] Reuters, "Russia cuts Kyrgyz debt for military, power deals," *Reuters*, 2012, available at: https://www.reuters.com/article/russia-kyrgyzstan/russia-cuts-kyrgyz-debt-for-military-power-deals-idUSL5E8KK15720120920 (accessed 18 February 2018).

[1273] Dinara Taldybayeva, "Prospects for China – Kyrgyzstan Economic Relations in the Framework of the Silk Road Economic Belt Project," *HKTDC Research*, 2017, available at: http://china-trade-research.hktdc.com/business-news/article/The-Belt-and-Road-Initiative/Prospects-for-China-Kyrgyzstan-Economic-Relations-in-the-Framework-of-the-Silk-Road-Economic-Belt-Project/obor/en/1/1X000000/1X0A9JIX.htm (accessed 17 February 2018).

[1274] World Bank, "World Development Indicators," *The World Bank Databank*, 2017, available at: http://data.worldbank.org (accessed 31 January 2017). Renewable energy consumption is on the right axis.

After the dissolution of the Soviet Union, renewable electricity generation in Central Asia increased.[1275] Kyrgyzstan produces 93 percent of its total electricity from hydro sources, while this share was 99 percent in Tajikistan by 2012. As compared to the 1991 levels, there is a significant increase in the region (Figure 6.8),[1276] also including Uzbekistan and Kazakhstan.

The upstream countries in the Aral Sea basin plan to generate electricity from hydro resources to meet the internal demand and export the excess electricity despite some concerns emanating from agricultural demand in the downstream countries. There is an existing infrastructure in the region for electricity trade, as discussed in the following paragraphs.

6.4.2. Interconnections

The Central Asian Power System (CAPS) is a web of generators and power transmission lines established during the 1970s and 1980s. The system connected the electricity grids of five Central Asian countries (Figure 6.9), until it became gradually dysfunctional in about one decade after the collapse of the Soviet Union.[1277] Turkmenistan left the CAPS in 2003 because of a disparity with Uzbekistan about electricity transfers to Kazakhstan. Tajikistan abandoned in November 2009 and disconnected the two 500 kV transmission lines to Uzbekistan (the Guzar-Regar and the Surkhan-Regar lines). Uzbekistan is connected to Northern Tajikistan via

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[1275] Teresa Malyshev, "Market Deployment of Renewable Energy in Central Asia: Implications for Energy Diversification," in A. Iacomelli, ed. *Renewable energies for central Asia countries economic, environmental and social impacts* Series IV: Earth and Environmental Sciences ed., 2005, p.59.

[1276] The Regional Environmental Centre for Central Asia, Energy Efficiency Assessment of Household Electrical Appliances in Central Asia and Policies for Energy Performance Standards and Labeling, The Regional Environmental Centre for Central Asia, 2015, p.21.

[1277] Amanda Wooden, "Kyrgyzstan's Dark Ages: Framing and the 2010 Hydroelectric Revolution," *Central Asian Survey*, vol. 33, no. 4, 2014, p.471.

220 kV and 110 kV lines and electricity exports continue on small scale.[1278] Also, Uzbekistan provides the transit of electricity from the south to the north of Kyrgyzstan, where the generators are not directly connected. As a compensation for this transit service, Kyrgyzstan supplies hydropower and regulation services for Uzbekistan. However, the CAPS is practically dysfunctional although there are limited transactions between Tajikistan, Uzbekistan, and Kyrgyzstan.[1279]

The CAPS does not involve the northern part of Kazakhstan. In terms of electricity grid, the country is divided into southern and northern sections, and the north is interconnected with the Russian grid. To connect these two sections, a 500 kV transmission line was constructed after the independence.[1280] Although the CAPS and the Russian grids are therefore theoretically connected, this connection is not capable to balance the demand and supply between the two grids.[1281]

[1278] World Bank, *Load dispatch and system operation study in Central Asian power system*, 2010, available at: http://documents.worldbank.org/curated/en/2015/08/24901339/load-dispatch-system-operation-study-central-asian-power-system (accessed 13 November 2015), p.14.

[1279] World Bank, *Load dispatch and system operation study in Central Asian power system*, 2010, available at: http://documents.worldbank.org/curated/en/2015/08/24901339/load-dispatch-system-operation-study-central-asian-power-system (accessed 13 November 2015), pp.23-24; Siegfried Grunwald, *Central Asia Regional Economic Cooperation: Power Sector Regional Master Plan*, Asian Development Bank, 2012, available at: http://www.adb.org/projects/documents/central-asia-regional-economic-cooperation-power-sector-regional-master-plan-tacr (accessed 17 November 2015).

[1280] Joellyn Murphy, "The Central Asian Power System: An Existing International Power Grid That's Still Missing an Integrative, Market-Based Trading Regime," in *Regional Energy Trade Workshop*., 2014.

[1281] World Energy Council, *Electricity in Central Asia: Market and Investment Opportunity Report*, 2007, available at: https://www.worldenergy.org/wp-content/uploads/2012/10/PUB_Asia_Regional_Report_Electricty_Market_And_Investment_Opportunity_2007_WEC.pdf (accessed 17 November 2015), p.22.

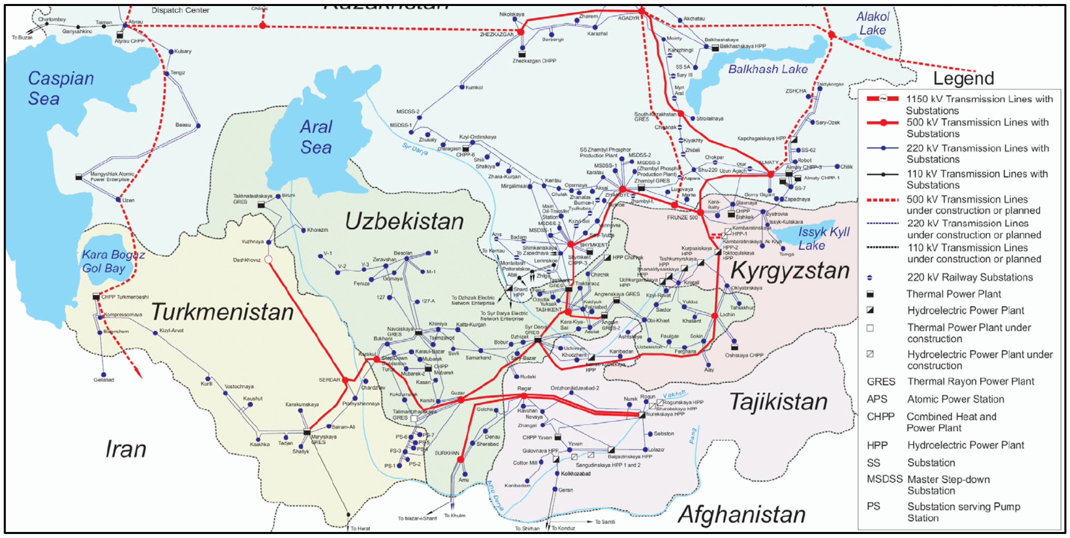

Figure 6.9. The map of the Central Asian Power System[1282]

Uzbekistan was the key country for the CAPS before the withdrawal of Turkmenistan and Tajikistan. Uzbekistan contributed about 52 percent to the system, while Tajikistan, Kyrgyzstan, Turkmenistan and South Kazakhstan contributed 16, 15, 11 and 6 percent, respectively.[1283] Uzbekistan has also been the greatest exporter, as well as the greatest consumer of electricity within the system, with an average of 42 billion kWh per annum in the last two decades as of 2012 (Figure 6.11).[1284] Estimates show that the Uzbek electricity demand would increase by an average of 3 percent annually, reaching to 65.7 TWh per year in 2021 and to 88.3 TWh in 2031.

[1282] Global Energy Network Institute, "Central Asian Grid," 2015, available at: http://www.geni.org/globalenergy/library/national_energy_grid/central-asia/central-asian-electricitygrid.shtml (accessed 17 November 2015).

[1283] World Energy Council, *Electricity in Central Asia: Market and Investment Opportunity Report*, 2007, available at: https://www.worldenergy.org/wp-content/uploads/2012/10/PUB_Asia_Regional_Report_Electricty_Market_And_Investment_Opportunity_2007_WEC.pdf (accessed 17 November 2015), p.21.

[1284] US Energy Information Administration, "International Energy Statistics," 2012, available at: http://www.eia.gov (accessed 20 November 2015).

Similarly, Southern Kazakhstan electricity demand is estimated to increase about 4 percent per year, reaching to 23.8 TWh by 2021 and 34.5 TWh by 2031.[1285]

Regional electricity integration and electricity generation, as well as load balance optimization were the intended benefits of the CAPS that functioned well until the independence. Just after the collapse of the Soviet Union, the electricity consumption and generation in the former Soviet Union declined sharply as a consequence of the economic crisis following the disintegration. Although the figures recovered in the following decade, electricity exchanges through the CAPS declined more than 90 percent since 1990 (Figure 6.10).

As stated above, most of the power infrastructure in Kyrgyzstan was installed during the Soviet era and needs updates. For example, the Toktogul reservoir was commissioned in 1974 and the Uch-Kurgan Dam is already more than 30 years old.[1286] Lack of enough financing delayed the rehabilitation projects as the required estimated investments totaled around 0.8 billion US dollars by 2008.[1287] According to some authors, "parts of the system came near collapse" by 2014.[1288] This results in large losses of electricity during transfers. The loss is estimated to be around 25

1285 Siegfried Grunwald, *Central Asia Regional Economic Cooperation: Power Sector Regional Master Plan*, Asian Development Bank, 2012, available at: http://www.adb.org/projects/documents/central-asia-regional-economic-cooperation-power-sector-regional-master-plan-tacr (accessed 17 November 2015), pp.2-18.

1286 Global Energy Observatory, 2015, available at: http://www.globalenergyobservatory.org/constructNetworkIndex.php (accessed 15 November 2015).

1287 N. Abdyrasulova & N. Kravsov, *Electricity Governance in Kyrgyzstan: An Institutional Assessment*, 2009, available at: http://electricitygovernance.wri.org/files/egi/Kyr_EGI_FINAL_5.6.10.pdf (accessed 15 November 2015), p.15.

1288 David Gullette & Jeanne Féaux de la Croix, "Mr Light and people's everyday energy struggles in Central Asia and the Caucasus: an introduction," *Central Asian Survey*, vol. 33, no. 4, 2014, p.439.

percent in the Kyrgyzstan grid in 2012.[1289] Also, there are severe stability problems in the whole CAPS infrastructure that occasionally lead to disconnections.[1290]

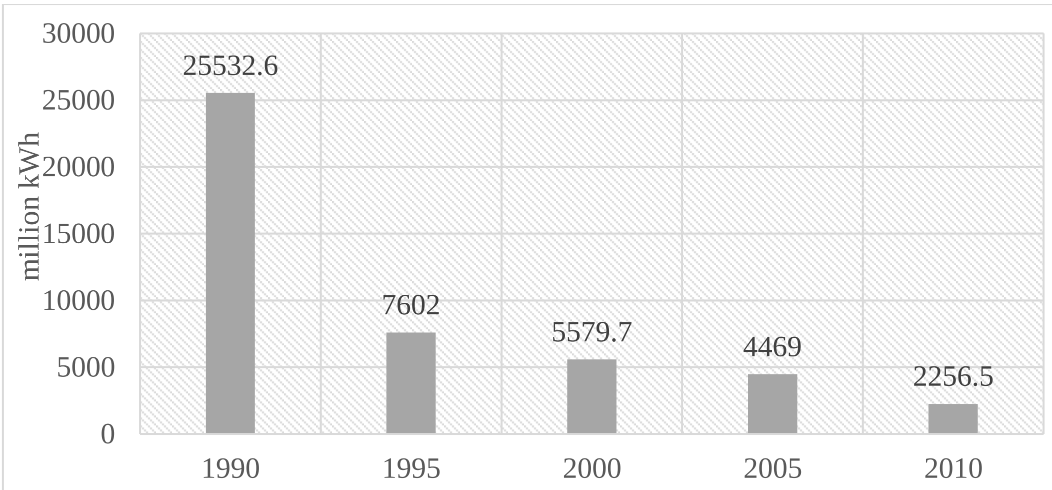

Figure 6.10. Power exchanges in the CAPS[1291]

[1289] The Regional Environmental Centre for Central Asia, Energy Efficiency Assessment of Household Electrical Appliances in Central Asia and Policies for Energy Performance Standards and Labeling, The Regional Environmental Centre for Central Asia, 2015, p.22. See also: James Dorian, "Central Asia: A major emerging energy player in the 21st century," Energy Policy, vol. 34, no. 5, 2006, pp.549-52.

[1290] World Bank, *Load dispatch and system operation study in Central Asian power system*, 2010, available at: http://documents.worldbank.org/curated/en/2015/08/24901339/load-dispatch-system-operation-study-central-asian-power-system (accessed 13 November 2015), p.20.

[1291] US Energy Information Administration, "International Energy Statistics," 2012, available at: http://www.eia.gov (accessed 20 November 2015); Energy Charter, *Price of Electricity Transit in Transition Countries*, 2014, available at: http://www.energycharter.org/what-we-do/trade-and-transit/trade-and-transit-thematic-reports/price-of-electricity-transit-in-transition-countries-2014/ (accessed 22 November 2015).

After the independence, most of the electricity trade took place between Kyrgyzstan and South Kazakhstan. During the 2000s, Kyrgyzstan transferred 1.6 GWh of electricity to Southern Kazakhstan per year, on average terms,[1292] through two 500 kV and four 200 kV transmission lines (Figure 6.9).[1293]

Kyrgyzstan's aged electricity infrastructure, which is in urgent need for maintenance and restoration, involves both power production and transmission facilities.[1294] On the other hand, the lack of financing is a major setback for both the Kyrgyzstan government and for the regional electricity integration. Furthermore, the non-favorable political situation in the region is a hindrance for improving electricity integration. Thus, after the water and electricity development projects of Kyrgyzstan finalized, the country may not find opportunities to export excess electricity to Central Asian countries. In such a case, China may be a viable alternative market for Kyrgyz electricity.

[1292] Siegfried Grunwald, *Central Asia Regional Economic Cooperation: Power Sector Regional Master Plan*, Asian Development Bank, 2012, available at: http://www.adb.org/projects/documents/central-asia-regional-economic-cooperation-power-sector-regional-master-plan-tacr (accessed 17 November 2015), pp.3-5.

[1293] World Bank, *Load dispatch and system operation study in Central Asian power system*, 2010, available at: http://documents.worldbank.org/curated/en/2015/08/24901339/load-dispatch-system-operation-study-central-asian-power-system (accessed 13 November 2015), p.13.

[1294] Siegfried Grunwald, *Central Asia Regional Economic Cooperation: Power Sector Regional Master Plan*, Asian Development Bank, 2012, available at: http://www.adb.org/projects/documents/central-asia-regional-economic-cooperation-power-sector-regional-master-plan-tacr (accessed 17 November 2015), pp.9-5.

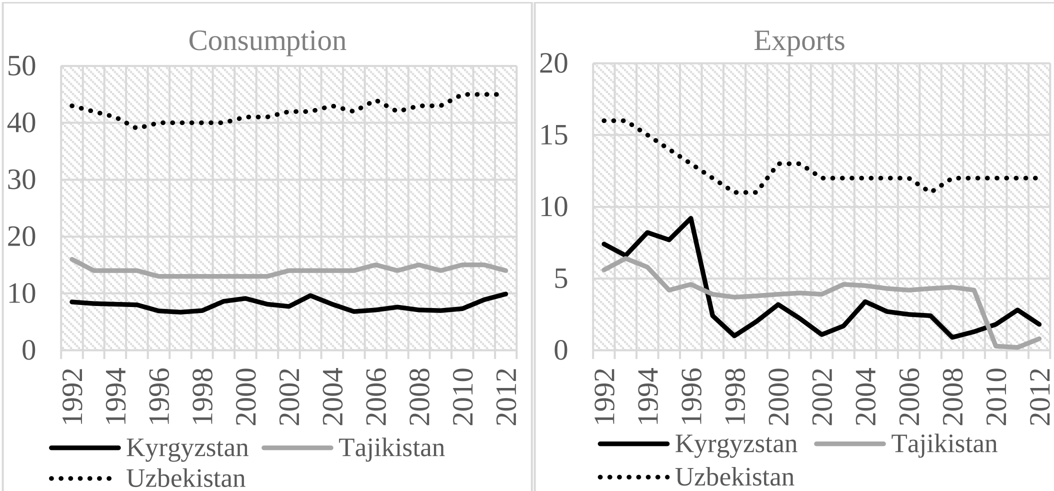

Figure 6.11. Electricity consumption and exports in CAPS (billion kWh)[1295]

In the 2010s, with the support and long-term loans from China, the Chinese Tebian Electric Apparatus Stock Company constructed the Datka-Kemin transmission line with a cost of 390 million US dollars. With this line, the dependency of Kyrgyz electricity grid decreased on the transmission lines passing through Uzbekistan, for which the government of Kyrgyzstan paid transmission fees.[1296] More importantly, with the "One Belt One Road" initiative of the Chinese government, the Central Asian countries are expected to receive significant amounts of infrastructure investments in multiple sectors, including transportation, electricity generation, and electricity transfers.[1297]

[1295] US Energy Information Administration, "International Energy Statistics," 2012, available at: http://www.eia.gov (accessed 20 November 2015).

[1296] Asia News, "Chinese-funded project gives Kyrgyzstan its first independent power transmission line," *AsiaNews.it*, 2015, available at: http://www.asianews.it/news-en/Chinese-funded-project-gives-Kyrgyzstan-its-first-independent-power-transmission-line-35168.html (accessed 13 October 2017).

[1297] Bruce Pannier, "Majlis Podcast: What Does China's One Belt, One Road Project Mean For Central Asia?," *RFL/RL*, 2016, available at: https://www.rferl.org/a/china-obor-project/28112031.html (accessed 3 February 2018); Catherine Putz, "What's Next for the Belt and Road in Central Asia?," *The Diplomat*, 2017, available at: https://thediplomat.com/2017/05/whats-

Besides the Russian energy firms, which supported the Kambarata-1 and the Rogun projects, some US firms grew interest in the region although their weight remained on marginal levels as compared to the multibillion-dollar investment program of the Chinese government. Still, the ongoing CASA-1000 project involves significant investments in electricity transmission infrastructure of Kyrgyzstan, Tajikistan, Pakistan, and Afghanistan. In the pipeline is the 500 kV transmission line from Datka in Kyrgyzstan to Sugd in Tajikistan (Figure 6.12).[1298]

Figure 6.12. A map of the CASA-1000 project

next-for-the-belt-and-road-in-central-asia/ (accessed 16 February 2018); Dinara Taldybayeva, "Prospects for China – Kyrgyzstan Economic Relations in the Framework of the Silk Road Economic Belt Project," *HKTDC Research*, 2017, available at: http://china-trade-research.hktdc.com/business-news/article/The-Belt-and-Road-Initiative/Prospects-for-China-Kyrgyzstan-Economic-Relations-in-the-Framework-of-the-Silk-Road-Economic-Belt-Project/obor/en/1/1X000000/1X0A9JIX.htm (accessed 17 February 2018).

[1298] CASA-1000 Project, "Realizing the CASA-1000 Vision," *CASA-1000*, 2017, available at: http://www.casa-1000.org/MainPages/CASAAbout.php#vision (accessed 19 February 2018).

As of 2016, at least 15 small HPPs with a total of 45.6 megawatts installed capacity are in operation in Kyrgyzstan.[1299] Small HPPs may be a viable policy option for Kyrgyzstan under the current hydropolitical circumstances in Central Asia.[1300] In accordance, Kyrgyzstan plans to build a number of small HPPs,[1301] which are also supported by international organizations.[1302] Also, after the finishing of the Kambarata-1 HPP, coordinated operation of Kambarata and Toktogul reservoirs may be another option. Since the Kambarata cascade will be located upstream of the Toktogul Reservoir, water released for generating electricity can be stored in the Toktogul during the winter. This may prevent the occurrence of floods in Uzbekistan during the winter season.

6.5. Conclusion

In the Aral Sea basin, Kyrgyzstan has an upstream position, where about three-quarters of the Syr Darya waters originate. In this largest endorheic river basin of Central Asia, the downstream countries are economically dependent on waters of the basin rivers. Most of the water is withdrawn by the agricultural sector in Uzbekistan and Turkmenistan. During the Soviet era, barter mechanisms, including the CAPS, were established for supporting the sustainability of downstream irrigated agriculture and upstream energy requirements.

[1299] World Bank Energy and Extractives Global Practice, *Small Hydro Power Plant in the Kyrgyz Republic: Assessment of Potential and Development Challenges*, The World Bank and the International Finance Corporation, 2017, p.9.

[1300] Joelle Rizk & Berdakh Utemuratov, *Balancing the Use of Water Resources in the Amu Darya Basin*, 2012, available at: http://amudaryabasin.net/resources/balancing-use-water-resources-amu-darya-basin (accessed 21 November 2015), p.10.

[1301] AKIpress, "Tender for construction of 14 small hydropower plants announced in Kyrgyzstan," *AKIpress*, 2017, available at: https://akipress.com/news:593096/ (accessed 11 February 2018).

[1302] See, for instance: UNDP, "Small Hydro Power Development," *Kyrgyz Republic*, 2018, available at: http://www.kg.undp.org/content/kyrgyzstan/en/home/operations/projects/sustainable_development/small-hydro-power-development.html (accessed 17 February 2018).

As the CAPS that once connected the electricity grids of the five Central Asian states is currently dysfunctional and the stability and future of the CAPS is unclear, Tajikistan[1303] and Kyrgyzstan have long been seeking for alternative ways of developing the existing electricity generation and transmission infrastructure and of establishing new routes for future electricity exports. As the dominant downstream, Uzbekistan opposes these projects based on the concerns on water supply security. On the other hand, regional electricity integration and the reestablishment of a common electricity market is still the most viable option for the solution of political disputes caused by transboundary water development projects between the riparians in the Aral Sea basin. The already existing CAPS establishes the technical infrastructure for such an integration despite its aged and degraded condition, while the regional water agreements and the institutions such as the ICWC establish the legal and institutional infrastructure. On the other hand, for Kyrgyzstan, the CAPS is not the only option as the US- and China-backed projects including the hydropower sector in the region have gained pace.

[1303] Despite recent bilateral agreement for electricity trade between Uzbekistan and Tajikistan, the Guzar-Regar line remains disconnected as of early 2018. See: Asia-Plus, "Dushanbe and Tashkent reportedly reach agreement on delivery of Tajik electricity to Uzbekistan," *Asia-Plus*, 2018, available at: https://news.tj/en/news/tajikistan/economic/20180228/dushanbe-and-tashkent-reportedly-reach-agreement-on-delivery-of-tajik-electricity-to-uzbekistan (accessed 28 February 2018).

CHAPTER VII

EGYPT

> So much power running to waste, such a coign of vantage unoccupied, such a lever to control the natural forces of Africa ungripped, cannot but vex and stimulate imagination. And what fun to make the immemorial Nile begin its journey by driving through a turbine!
>
> Winston Churchill, 1908[1304]

> The next war in the Middle East will be fought over water, not politics.
>
> Boutros Boutros Ghali, 1985[1305]

7.1. Introduction

The Nile River basin is one of the most critical locations in the world where politics and water issues are often on the crossroads. The students of the Nile basin often use water and conflict together in their writings. The history of the basin, especially the highly politicized Cold War era, is full of examples of water determining politics and politics determining water issues. This is a major reason why the region have become one of the main cases in the academic studies on hydro-hegemony and on conflictual relations in transboundary river basins.

[1304] Heather Hoag, *Developing the Rivers of East and West Africa: An Environmental History* (London: Bloomsbury, 2013), p.125.

[1305] BBC, "Talking Point: Ask Boutros Boutros Ghali," *BBC News*, 2003, available at: http://news.bbc.co.uk/2/hi/talking_point/2951028.stm (accessed 23 September 2017).

The Nile River basin is one of the greatest river basins in the world. This chapter studies the water development projects and electricity interconnections in this basin with an emphasis on the largest but most water-dependent economy in the region. Throughout the history, this dependence led the Egyptian rulers put political pressure on the upstream countries to secure and maintain water supply and rights. On the other hand, the traditional hydropolitical balance tends to change in the region as the less developed countries bid for more water and more energy as their economies grow.

7.2. Physical characteristics

The Nile is the second longest river in the world. The water of the Nile River flows in the south-north direction as a general trend, flowing from the southern hemisphere to the northern hemisphere, and carrying the water from the equatorial lakes and rain forests through the barren deserts of the North Africa, towards the Mediterranean Sea. The geographical features of the river basin are decisive factors on the hydropolitical relations and the economies of the riparians, as discussed in the following paragraphs. More than 95 percent of the Egyptians live in the Nile valley.[1306] Particularly, only about 4 percent of the Egyptian territory on the banks of the Nile is suitable for agriculture and irrigation, and the rest are deserts.[1307]

7.2.1. Geography and main regional features

The Nile River flows through eleven different political entities. Burundi, Democratic Republic of Congo, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, South Sudan, the Sudan, Tanzania, and Uganda are located in the catchment zone of the river basin. Regarding surface area, the Sudan was the largest country in the basin before the secession of the South. After the independence of the South Sudan in 2011, Democratic Republic of Congo is the largest, with a surface area wider than 2.3

[1306] Jutta Brunnée & Stephen Toope, "The Changing Nile Basin Regime: Does Law Matter?," *Harvard International Law Journal*, vol. 43, no. 1, 2002, p.118.

[1307] Asit Biswas, "Aswan Dam Revisited: The Benefits of a Much Maligned Dam," *Development and Cooperation*, vol. 6, 2002, p.25.

million square kilometers. Of this enormous area, only less than 1 percent can be involved into the basin (Table 7-1). In contrast, the catchment area of the Nile covers almost the entire surface areas of some countries, i.e. 98 percent of South Sudan and Uganda lay within the basin.

Within the basin, the Sudan has 1.37 million square kilometers, which corresponds to about 44 percent of the total catchment area of the Nile River, which is about 3.1 - 3.4 million square kilometers.[1308] The Sudan and Egypt are considered as the downstream countries in the basin, while the remaining nine countries are in the upstream. In the literature, Egypt, the Sudan, South Sudan, Eritrea, and Ethiopia are mentioned as the Eastern Nile basin.[1309]

The Nile basin encompasses some unique landscapes. One example is the Equatorial Lake Plateau, which lies in the upstream Nile River basin. Six countries are on this plateau, entirely or partly: Burundi, Rwanda, Tanzania, Kenya, Democratic Republic of Congo, and Uganda.[1310] There are numerous lakes in this area within the basin. The largest of these is the Lake Victoria, the widest lake in Africa, with its 68.5 thousand square kilometers of surface area. In total, 23 rivers feed this lake.[1311] Other major lakes are the Edward, the George, the Kyoga, the Albert, the Turkana, in respective order from south to north. All these lakes are parts of the African Great

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1308 Food and Agriculture Organization of the United Nations, "The Nile Basin," *FAO Corporate Document Repository*, n.d., available at: http://www.fao.org/docrep/W4347E/w4347e0k.htm (accessed 10 April 2017).

1309 See: Getachew Nigatu & Ariel Dinar, "Economic and Hydrological Impacts of the Grand Ethiopian Renaissance Dam on the Eastern Nile River Basin," *Environment and Development Economics*, vol. 21, no. 4, 2015; Diane Arjoon, Yasir Mohamed, Quentin Goor & Amaury Tilmant, "Hydro-Economic Risk Assessment in the Eastern Nile River Basin," *Water Resources and Economics*, vol. 8, 2014.

1310 Food and Agriculture Organization of the United Nations, "The Nile Basin," *FAO Corporate Document Repository*, n.d., available at: http://www.fao.org/docrep/W4347E/w4347e0k.htm (accessed 10 April 2017).

1311 John Lehman, "Lake Victoria," in H.J. Dumont, ed. *The Nile: Origin, Environments, Limnology and Human Use* 1st ed., 2009, pp.215-16.

Lakes system, which was formed by the East African Rift. The lakes Edward, George, and Albert are connected to each other, among which the Lake George is shallow, with a maximum of 3.5 meters depth, while the Albert and the Edward have 58 and 117 meters maximum depths, in respective order.[1312] The Lake Turkana in the north of Kenya is the northernmost of the Great African Lakes and surrounded by deserts. It is deeper than the other three, with 120 meters of maximum depth.[1313] Another example is the Ethiopian Highlands, the highest place in the basin, which cover most of the territory of Ethiopia,[1314] but the major and highest source of the White Nile waters is another highland, the Rwenzori Mountains, between Uganda and the Democratic Republic of Congo.[1315] The famous marshland, the Sudd, lays within the boundaries of South Sudan and fed by the White Nile water.[1316]

Sir William Garstin investigated the White Nile in the early twentieth century for navigation possibilities through the Sudd, and proposed digging a canal in the east of the marshes.[1317] Decades after, in the 1950s, plans were drafted for the initiation

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[1312] Jim Green, "Nilotic Lakes of the Western Rift," in H.J. Dumont, ed. *The Nile: Origin, Environments, Limnology and Human Use* 1st ed., 2009, pp.263-64.

[1313] Thomas Johnson & John Malala, "Lake Turkana and Its Link to the Nile," in H.J. Dumont, ed. *The Nile: Origin, Environments, Limnology and Human Use* 1st ed., 2009, p.288.

[1314] Mohamed Hamouda, Mohamed El-Din & Fawzia Moursy, "Vulnerability Assessment of Water Resources Systems in the Eastern Nile Basin," *Water Resources Management*, vol. 23, 2009, p.2698.

[1315] Hilde Eggermont, Kay Damme & James Russell, "Rwenzori Mountains (Mountains of the Moon): Headwaters of the White Nile," in H.J. Dumont, ed. *The Nile: Origin, Environments, Limnology and Human Use* 1st ed., 2009.

[1316] Jutta Brunnée & Stephen Toope, "The Changing Nile Basin Regime: Does Law Matter?," *Harvard International Law Journal*, vol. 43, no. 1, 2002, p.117.

[1317] Robert Collins, "History, Hydropolitics and the Nile: Myth or Reality," in P.P. Howell & J.A. Allan, eds. *The Nile: Sharing a Scarce Resource - A Historical and Technical Review of Water Management and of Economical and Legal Issues*, 1994, pp.111-12; Hosam Elemam, "Egypt and Collective Action Mechanisms in the Nile Basin," in T. Tvedt, ed. *The River Nile in the Post-Colonial Age: Conflict and Cooperation among the Nile Basin Countries*, 2010, p.219.

of the project. The Egyptian and the Sudanese governments agreed on the Jonglei Canal scheme in 1974.[1318] According to the agreement, the “saved” water, as well as the cost of the project, would be shared equally by the Sudan and Egypt.[1319] The construction began with the concession from the Sudanese government in 1978, but it was stopped in 1984 because of some attacks by the Sudanese People’s Liberation Army[1320] and could not be completed since then. The Jonglei Canal project raised some environmental concerns from the early days it was initiated and became highly politicized. It was associated with the political conflict between the Sudan and South Sudan.[1321] On the other hand, recent studies estimate that there would be no significant increase in the river runoff had the Jonglei Canal been completed, yet the impacts on the regional climate would have been significant. According to Mohamed et al., the relative humidity would decrease and the dry season temperature would increase by 4 to 6 degrees Celsius.[1322]

1318 Rushdi Said, *The River Nile: Geology, Hydrology and Utilization* (Oxford: Pergamon Press, 1993), p.225.

1319 Rushdi Said, *The River Nile: Geology, Hydrology and Utilization* (Oxford: Pergamon Press, 1993), p.227.

1320 Ashok Swain, "Ethiopia, the Sudan, and Egypt: The Nile River Dispute," *The Journal of Modern African Studies*, vol. 35, no. 4, 1997, p.682.

1321 Jutta Brunnée & Stephen Toope, "The Changing Nile Basin Regime: Does Law Matter?," *Harvard International Law Journal*, vol. 43, no. 1, 2002, p.126.

1322 Y. Mohamed, B. Hurk, Hubert Savenije & W.G.M. Bastiaanssen, "Impact of the Sudd wetland on the Nile hydroclimatology," *Water Resources Research*, vol. 41, no. 8, 2005.

Table 7-1. Land area of the countries within the Nile River basin[1323]

	TFDD	TWAP
Burundi	12.853	13
D.R. Congo	21.103	20
Egypt	276.572	214
Eritrea	3.561	8
Ethiopia	354.887	357
Kenya	50.69	50
Rwanda	20.628	21
Sudan	1921.857	1892
Tanzania	119.397	120
Uganda	237.524	237
Total	3,019.072	2,932

The Nile River passes through a variety of climate zones.[1324] Most of Egypt, Eritrea, and the Sudan are deserts, the former having an average of 15 millimeters of rain annually.[1325] This represents a great contrast to the remaining of the region where the headwaters are located, with more than 1,000 millimeters of average annual rainfall.[1326] There are tropical and subtropical parts, as well as arid and semi-arid

[1323] In thousand square kilometers. The sources in respective order: TFDD: Oregon State University, "Nile Basin," *Transboundary Freshwater Dispute Database*, 2009, available at: http://gis.nacse.org/tfdd/map/result.php?bcode=NILE (accessed 25 April 2017); TWAP: UNEP/GEF, "TWAP," *Transboundary Waters Assessment Programme*, 2017, available at: http://www.geftwap.org/twap-project (accessed 18 April 2017).

[1324] See, for a detailed narrative of the Nile basin climate in Egypt: W. Willcocks & James Craig, *Egyptian Irrigation* (London: Spon, 1913), pp.11-26.

[1325] Food and Agriculture Organization of the United Nations, "The Nile Basin," *FAO Corporate Document Repository*, n.d., available at: http://www.fao.org/docrep/W4347E/w4347e0k.htm (accessed 10 April 2017).

[1326] Food and Agriculture Organization of the United Nations, "The Nile Basin," *FAO Corporate Document Repository*, n.d., available at: http://www.fao.org/docrep/W4347E/w4347e0k.htm (accessed 10 April 2017).

lands, along with a Mediterranean climate zone, within the basin.[1327] Most of the Sudan and all of Egypt are in the arid and desert climate zone, according to the Köppen-Geiger classification.[1328] Especially the high levels of aridity in the north of the Sudan and Egypt make them dependent on the Nile waters.

The Nile River is one of the two longest rivers in the world, measured at about 6,700 kilometers.[1329] Its basin encompasses an enormous area wider than 3.1 million square kilometers. It has a discharge of 1.6 thousand cubic meters per second, or about 94 cubic kilometers per annum (including evaporation), at its mouth.[1330] The mainstream of the river emerges as a combination of some big rivers upstream, among which the White Nile, the Blue Nile, the Atbara, and the Sobat are the largest. The capital of the Sudan, Khartoum, is where the two largest tributaries of the Nile, the Blue and the White, merge into one water body to establish the mainstream. After Khartoum, the river flows in the Sudan, then enters Egypt from the south, and discharges into the Mediterranean Sea, near Cairo.[1331] The primary source of the Nile River is Ethiopia as nearly 85 percent of all its water has origins in this country.[1332]

[1327] Reem Digna, et al., "Nile River Basin Modelling for Water Resources Management – A Literature Review," *International Journal of River Basin Management*, vol. 15, no. 1, 2017, p.42.

[1328] Markus Kottek et al., "World Map of the Köppen-Geiger Climate Classification Updated," *Meteorologische Zeitschrift*, vol. 15, no. 3, 2006.

[1329] Sources differ in the ranking of the Nile and Amazon rivers.

[1330] Laura Parkes, "The Politics of 'Water Scarcity' in the Nile Basin: the Case of Egypt," *Journal of Politics & International Studies*, vol. 9, 2013, pp.438-42.

[1331] See, for an early account of Egyptian landscape: W. Willcocks & James Craig, *Egyptian Irrigation* (London: Spon, 1913).

[1332] Jutta Brunnée & Stephen Toope, "The Changing Nile Basin Regime: Does Law Matter?," *Harvard International Law Journal*, vol. 43, no. 1, 2002, p.117; Reem Digna, et al., "Nile River Basin Modelling for Water Resources Management – A Literature Review," *International Journal of River Basin Management*, vol. 15, no. 1, 2017, p.42.

Before discharging into the Mediterranean Sea, the Nile establishes a delta with a surface area of around 30 thousand square kilometers. Around Cairo, the river splits into two main branches, named the Damietta and the Rosetta. Between Khartoum in the Sudan and Aswan, the Nile is divided into six cataracts. The First Cataract is in Egypt and the five in the Sudan.

The abovementioned Equatorial Lake Plateau is the source of the White Nile. It originates from the Owen Falls Dam in Uganda, north of the Lake Victoria, as the only effluent out of the lake under the name of the Victoria Nile. The Victoria Nile is the largest contributor to the Nile waters. This is a reason why the Lake Victoria was long thought to be the ultimate source of the Nile.[1333] However, the ultimate source of the Nile is known to be further in the southwest as the Lake Victoria is fed by some other rivers, not solely by precipitation. Among the feeders, the Akanyaru, the Ruvubu (or the Rurubu), and the Nyabarongo (or the Nyawarungu) rivers confluence into the Kagera (or Akagera)[1334] River on the border between Rwanda and Tanzania. The Nyabarongo begins in the Nyungwe rain forest in the southwest of Rwanda, the Ruvubu rises from the north of Burundi, and the Akanyaru rises in the highlands of Rwanda and Burundi. Lake Rweru in the north of Burundi is also a feeder of the Kagera River.

The Kagera drains into the Lake Victoria from its western shores, near the southernmost border of Uganda. The annual contribution of the Kagera to the Lake Victoria is 7.5 cubic kilometers, while the total inflow into the lake is about 20 cubic kilometers, annually.[1335] From the huge Lake Victoria flows out the Victoria

[1333] Henri Dumont, "A Description of the Nile Basin, and a Synopsis of its History, Ecology, Biogeography, Hydrology, and Natural Resources," in H.J. Dumont, ed. *The Nile: Origin, Environments, Limnology and Human Use* 1st ed., 2009, p.2.

[1334] Terje Tvedt, *The River Nile in the Post-colonial Age: Conflict and Cooperation Among the Nile Basin Countries* (London, New York: I.B.Tauris, 2009), pp.32-33.

[1335] Food and Agriculture Organization of the United Nations, "The Nile Basin," *FAO Corporate Document Repository*, n.d., available at: http://www.fao.org/docrep/W4347E/w4347e0k.htm (accessed 10 April 2017).

Nile, reching first into the Lake Kyoga, which is further fed by the streams from the Mount Elgon,[1336] then into Lake Albert, which is also fed by the Semliki River,[1337] and then, under the name of the White Nile, or the Albert Nile, it flows through Uganda into the infamous Sudd swamps and into the Lake No in South Sudan, where almost half of the water gets "lost."[1338] In South Sudan, the river gets the name Bahr el Jebel, and at the Lake No, it confluences with the Bahr el Gazal. Then, it enters into the Sudanese territory from the south. Two major rivers, the Dinder and the Rahad join the White Nile in the Sudan.

The White Nile is also indirectly fed by rainwater and melting glaciers of the Rwenzori Mountains.[1339] The numerous small rivers originating from the Rwenzori Mountains contribute to the waters of the lakes George, Edward, and Albert to a significant degree. These rivers contribute about 1 billion cubic meters of water to the Lake George alone annually, according to the measurements in the 1960s.[1340] These three lakes, in turn, are the major feeders of the White Nile River.

The source of the Blue Nile is the Lake Tana, with its 3,050 square kilometers of surface area. In total, 7 permanent and 40 seasonal streams flow into the lake.

[1336] Jim Green, "The Kyoga Catchment," in H.J. Dumont, ed. *The Nile: Origin, Environments, Limnology and Human Use* 1st ed., 2009, p.205.

[1337] Food and Agriculture Organization of the United Nations, "The Nile Basin," *FAO Corporate Document Repository*, n.d., available at: http://www.fao.org/docrep/W4347E/w4347e0k.htm (accessed 10 April 2017).

[1338] Food and Agriculture Organization of the United Nations, "The Nile Basin," *FAO Corporate Document Repository*, n.d., available at: http://www.fao.org/docrep/W4347E/w4347e0k.htm (accessed 10 April 2017).

[1339] Hilde Eggermont, Kay Damme & James Russell, "Rwenzori Mountains (Mountains of the Moon): Headwaters of the White Nile," in H.J. Dumont, ed. *The Nile: Origin, Environments, Limnology and Human Use* 1st ed., 2009, p.245.

[1340] Hilde Eggermont, Kay Damme & James Russell, "Rwenzori Mountains (Mountains of the Moon): Headwaters of the White Nile," in H.J. Dumont, ed. *The Nile: Origin, Environments, Limnology and Human Use* 1st ed., 2009, p.255; Jim Green, "Nilotic Lakes of the Western Rift," in H.J. Dumont, ed. *The Nile: Origin, Environments, Limnology and Human Use* 1st ed., 2009, p.263.

Among the major tributaries are the Little Nile, the Megech, the Gumara, and the Rib rivers. The Blue Nile is the only effluent from the lake.[1341] Another major tributary of the Nile, the Atbara River, originates from Ethiopia, just in the north of the Lake Tana, and was joined by the Tekeze River before draining into the Nile.

7.2.2. Local institutions and regulations

The Nile River basin has been subject to numerous international agreements since the colonial era. Britain had sponsored most of these legal arrangements, and in general, they favored Egyptian (read British) interests, as discussed further in the following section. Under current legal regulations, water is allocated between the downstream riparians, Egypt and the Sudan. These agreements, in force since 1959,[1342] have been challenged by the upstream countries since the early post-colonial era.[1343]

The post-colonial era in Africa was one of the best examples of the relationship between politics and water issues. Tvedt calls this era in the Nile basin history as a period of "legal battles."[1344] One major subject of this legal disagreement was the legal status of the colonial era international agreements.[1345] According to the current regulations, Egypt has the right of using 55.5 cubic kilometers of the Nile water

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[1341] Jacobus Vijverberg, Ferdinand Sibbing & Eshete Dejen, "Lake Tana: Source of the Blue Nile," 2009, p.164.

[1342] "Agreement between the Republic of the Sudan and the United Arab Republic for the full utilization of the Nile waters" 1959,.

[1343] For a discussion on the efficacy of the water treaties in the Nile river basin, see: Wuhibegezer Ferede & Sheferawu Abebe, "The Efficacy of Water Treaties in the Eastern Nile Basin," *Africa Spectrum*, vol. 49, no. 1, 2014. The older water treaties will be discussed in some detail in the following section.

[1344] Terje Tvedt, "About the Importance of Studying the Modern History of the Countries of the Nile Basin in a Nile Perspective," in T. Tvedt, ed. *The River Nile in the Post-Colonial Age: Conflict and Cooperation in the Nile Basin Countries*, 2010, p.10.

[1345] Terje Tvedt, "About the Importance of Studying the Modern History of the Countries of the Nile Basin in a Nile Perspective," in T. Tvedt, ed. *The River Nile in the Post-Colonial Age: Conflict and Cooperation in the Nile Basin Countries*, 2010, p.10.

in a year, while 18.5 cubic kilometers were allocated to the Sudan. Although official reports argue that Egypt adheres its limits of 55.5 cubic kilometers of water, Cascão claims that the actual usage of Egypt should be much more. The possible reason why it announces a lesser amount than it actually uses is that it uses the share of the Sudan as well and this is a violation of international law if this is the case.[1346]

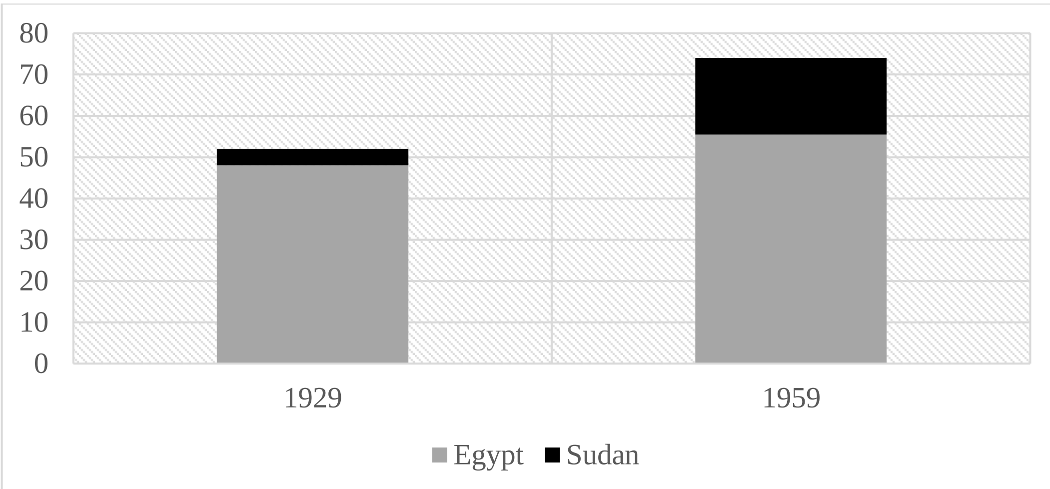

Figure 7.1. Sudan – Egypt water allocation according to international treaties[1347]

Since the 1960s, there have been initiatives and projects for cooperation in the Nile River basin. Some examples were the Hydromet Project (1967-1992) initiated by the UNDP for collecting hydrological and meteorological data on the Equatorial

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1346 Ana Cascão, "Changing Power Relations in the Nile River Basin: Unilateralism vs. Cooperation?," *Water Alternatives*, vol. 2, no. 2, 2009, p.247.

1347 In cubic kilometers per year. Based on the international treaties. See: "Agreement between the Republic of the Sudan and the United Arab Republic for the full utilization of the Nile waters" 1959, International Water Law Project, "Exchange of Notes between Her Majesty's Government in the United Kingdom and the Egyptian Government on the Use of Waters of the Nile for Irrigation," *International Water Law Project*, 1929, available at: http://www.internationalwaterlaw.org/documents/regionaldocs/Egypt_UK_Nile_Agreement-1929.html (accessed 11 March 2017).

Lakes;[1348] the Undugu Project (1983-1993) initiated by Egypt with the participation of Egypt, the Sudan, Democratic Republic of Congo, Uganda, and Central African Republic; the Technical Cooperation Committee of the Nile Basin (1992-1998) supported by the Canadian International Development Agency for the purpose of protection of the environment and economic development, with the participation of Egypt, the Sudan, Tanzania, Rwanda, Uganda, and Democratic Republic of Congo; and the Nile River Basin Cooperative Framework Project (1995-1997) open to all basin states and supported by the Canadian International Development Agency, along with the World Bank and the UNDP.[1349] A major and common setback to the proper functioning of these initiatives was that they were not all-encompassing. Furthermore, they did not establish the cooperation framework on an institutional basis.[1350] The Hydromet and the Undugu projects continued until 1992 and 1993, respectively.[1351]

Another important initiative in the Nile River basin is the Flow Regime from International Experimental and Network Data (FRIEND) Nile Project, initiated by the UNESCO in 1996. This is part of the greater global FRIEND project. The project aims at enhancing cooperation among the Nile riparians, data collection, and water resources management. Six countries are involved in the project, which are Egypt, the Sudan, Tanzania, Kenya, Uganda, and Ethiopia. The other countries may also

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[1348] Jane Baitwa, "A shared vision for the Nile Basin," *International Water Power & Dam Construction*, 2014, available at: http://www.waterpowermagazine.com/features/featurea-shared-vision-for-the-nile-basin-4291594/ (accessed 13 April 2017); Reem Digna et al., "Nile River Basin Modelling for Water Resources Management – A Literature Review," *International Journal of River Basin Management*, vol. 15, no. 1, 2017, p.40.

[1349] Reem Digna, et al., "Nile River Basin Modelling for Water Resources Management – A Literature Review," *International Journal of River Basin Management*, vol. 15, no. 1, 2017, p.40

[1350] Jane Baitwa, "A shared vision for the Nile Basin," *International Water Power & Dam Construction*, 2014, available at: http://www.waterpowermagazine.com/features/featurea-shared-vision-for-the-nile-basin-4291594/ (accessed 13 April 2017).

[1351] Reem Digna et al., "Nile River Basin Modelling for Water Resources Management – A Literature Review," *International Journal of River Basin Management*, vol. 15, no. 1, 2017, p.40.

contribute to the works of the project, led by the Egyptian Water Resources Research Institute. The project has thus far consisted of two major phases that continued between 2001 and 2006, and 2006 and 2011, respectively, all supported by various international organizations and donors. The first phase raised about 0.93 billion US dollars funding, while the second phase raised about 0.96 billion US dollars support.[1352]

Among the cooperation attempts, the Nile Basin Initiative (NBI), supported by the World Bank and many other international actors, is by far the most important and extensive, encompassing all the countries of the basin. As of 2017, the initiative has ten members and one observer, Eritrea. The NBI has a secretariat and two major programs, the Shared Vision Program, and the Subsidiary Action Program.[1353] The Secretariat is located at Entebbe, the Eastern Nile Technical Regional Office at Addis Ababa, and the Nile Equatorial Lakes Subsidiary Action Program Coordination Unit at Kigali.[1354] The Shared Vision Program includes eight themes, including water and the environment, power trade, agriculture, applied training, communication and stakeholder involvement, and benefit sharing.[1355] As for the Subsidiary Action Program, there are two offices: the Eastern Nile Technical Regional Office and the Nile Equatorial Lakes Subsidiary Action Program Coordination Unit. These two branches coordinate two major investment programs, the Eastern Nile Subsidiary

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[1352] UNESCO, "FRIEND/Nile," *UNESCO Office in Cairo*, 2017, available at: http://www.unesco.org/new/en/cairo/natural-sciences/hydrology-programme/friendnile/ (accessed 13 April 2017).

[1353] Reem Digna et al., "Nile River Basin Modelling for Water Resources Management – A Literature Review," *International Journal of River Basin Management*, vol. 15, no. 1, 2017, p.39.

[1354] Jane Baitwa, "A shared vision for the Nile Basin," *International Water Power & Dam Construction*, 2014, available at: http://www.waterpowermagazine.com/features/featurea-shared-vision-for-the-nile-basin-4291594/ (accessed 13 April 2017).

[1355] Nile Basin Initiative, "Shared Vision Program," *Nile Information System*, 2013, available at: http://nileis.nilebasin.org/user/login?destination=node%2F378 (accessed 12 April 2017).

Action Program (ENSAP) and the Nile Equatorial Lakes Subsidiary Action Program (NELSAP), respectively.[1356] The ENSAP involves the three Eastern Nile countries, Egypt, Ethiopia, and the Sudan, and the water ministers lead the program that aims at reducing poverty, stimulating economic growth, and reducing environmental degradation. The ENSAP is involved in a series of projects including, but not limited to, irrigation and drainage development, flood protection, integrated water resources management, and regional power trade.[1357] The Cooperative Framework Agreement of the NBI is a document that sets the principles of the water resources in the Nile basin. The agreement is envisaged to enter into force after the ratification of six countries. The signatures from six countries were successfully collected by 2011. These are all upstream countries. The Sudan and Egypt were absent by 2017.[1358] The reasons of this will be discussed in the following section.

All these institutions, international support, and initiatives are to regulate the water resources of the huge Nile River basin. These endeavors are vital for the upholding of the economies and the daily lives of the people within the basin. This economic structure in the region is a consequence of a long and complicated historical process, which will be summarized in the following section.

7.3. Water development projects in the Nile basin

Tight links between water and politics in the Nile River basin has made it subject to numerous case studies on hydro-hegemony, water security, and conflict.[1359] As

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[1356] Nile Basin Initiative, "Who We Are," *Nilebasin.org*, 2017, available at: http://www.nilebasin.org/index.php/nbi/who-we-are (accessed 12 April 2017).

[1357] Nile Basin Initiative, "Eastern Nile Subsidiary Action Program (ENSAP)," *Nile Information System*, 2013, available at: http://nileis.nilebasin.org/content/eastern-nile-subsidiary-action-program-ensap-0 (accessed 12 April 2017).

[1358] Nile Basin Initiative, "Cooperative Framework Agreement," *Nilebasin.org*, 2017, available at: http://nilebasin.org/index.php/new-and-events/105-nile-basin-initiative-launches-new-partnership-with-power-africa (accessed 12 April 2017).

[1359] See, for example: Mark Zeitoun & Jeroen Warner, "Hydro-hegemony: A Framework for Analysis of Trans-Boundary Water Conflicts," *Water Policy*, vol. 8, no. 5, 2006; Laura Parkes, observed by Selby and Hoffmann, within the water and conflict literature, the case of the Nile River basin has become subject to scrutiny "more than any other case," because of three main reasons: the pace of growth of population and economies of the Nile River basin countries, the dependence of the lower Nile countries on the basin waters, and a lack of water management institutions and regimes in the region.[1360] In general, the literature draws on the concept of power and scarcity, and stresses traditional power imbalances between the upstream and downstream countries.[1361] In the following paragraphs, the most prominent and politicized domestic and regional water issues will be discussed by following a historical path.

7.3.1. Background

Water is the source of one of the oldest civilizations in the world, in one of the most water-scarce regions globally. The earliest comprehensive waterworks around the Nile delta date back to nineteenth and eighteenth centuries, BC.[1362] The earliest irrigation method known to be applied in the delta is the basin irrigation method, in which flooded water of the river is diverted to the fields, where it is kept on soil for some six weeks to saturate the subsoil with enough water.[1363]

"The Politics of 'Water Scarcity' in the Nile Basin: the Case of Egypt," *Journal of Politics & International Studies*, vol. 9, 2013; Ana Cascao, "Ethiopia–Challenges to Egyptian hegemony in the Nile Basin," *Water Policy*, vol. 10, no. Supplement 2, 2008; Ana Cascão, "Changing Power Relations in the Nile River Basin: Unilateralism vs. Cooperation?," *Water Alternatives*, vol. 2, no. 2, 2009; Ashok Swain, "Challenges for Water Sharing in the Nile Basin: Changing Geo-Politics and Changing Climate," *Hydrological Sciences Journal*, vol. 56, no. 4, 2011; Dagmawi Degefu & Weijun He, "Water Bankruptcy in the Mighty Nile River Basin," *Sustainable Water Resources Management*, vol. 2, no. 1, 2016.

[1360] Jan Selby & Clemens Hoffmann, "Beyond scarcity: Rethinking water, climate change and conflict in the Sudans," *Global Environmental Change-human and Policy Dimensions*, vol. 29, 2014, p.363.

[1361] Ana Cascão, "Changing Power Relations in the Nile River Basin: Unilateralism vs. Cooperation?," *Water Alternatives*, vol. 2, no. 2, 2009.

[1362] W. Willcocks & James Craig, *Egyptian Irrigation* (London: Spon, 1913), p.300.

[1363] W. Willcocks & James Craig, *Egyptian Irrigation* (London: Spon, 1913), pp.299-301.

Egypt has been under the political rule of various nations, including Arabs, Turks, French, and British. The most remarkable and modern hydraulic works were initiated during the rule of Muhammad Ali Pasha. It was under the rule of him, in the early nineteenth century, when the ancient method of the basin irrigation system was replaced by the perennial irrigation system, a system of irrigation conducted through canals. Pasha used unpaid labor to build canals, including the Mahmudiyah Canal named after the Ottoman sultan. The works began in 1819, and the canal diverted water from the Nile River towards Alexandria, although it could not be as efficient as it was intended to due to various reasons.[1364] On the other hand, irrigation projects initiated by Muhammad Ali Pasha enabled Egyptians to cultivate cotton on large scale[1365] as cotton could not be raised through the application of basin irrigation method.[1366]

Large hydraulic projects continued after Muhammad Ali, among which were the Ismailia Canal constructed between 1858 and 1963,[1367] the Ibrahimiya Canal finished in 1873 under Ismail Pasha, the Delta Barrage initiated in 1833 and completed in 1861 constructed at a site where the Nile splits into two branches.[1368] The latter

[1364] "Public Works in Egypt," *The New Monthly Magazine*, vol. 113, no. 449, 1858, pp.1-2.

[1365] W. Willcocks & James Craig, *Egyptian Irrigation* (London: Spon, 1913), p.368; The New York Times, Egyptian Cotton: Its Modern Origin and the Importance of the Supply, 1864.

[1366] Hanbury Brown, *The Delta Barrage of Lower Egypt* (Cairo: National Printing Department, 1902), p.3.

[1367] See, for a discussion of this canal’s current situation, Mohamed Geriesh, Klaus-Dieter Balke & Ahmed El-Rayes, "Problems of drinking water treatment along Ismailia Canal Province, Egypt," *Journal of Zhejiang University Science B*, vol. 9, no. 3, 2008.

[1368] The Delta Barrage was among the most important structures in the delta region in Egypt. The design of the project belonged to Mougel Bey. Accordingly, the dam was to be placed on the site where the Rosetta and Damietta branches split from the Nile mainstream to establish the delta. The major sponsor of the project, Muhammad Ali Pasha, died in 1848 before the completion of the project. Mougel Bey was dismissed in 1853 by the successor of Muhammed Ali, Abbas Pasha, on the grounds that the project was progressing slowly, and replaced him by Mazhar Bey. Although the dam was completed in 1862, the foundations of this dam were found weak just after opening. After long discussions and after Sir Colin Scott Moncrieff became in 1883 the head of the Irrigation Department of Egypt, Sir William Willcocks coordinated the repairs of the dam in 1893. See:

was a project proposed much earlier, during the occupation of the French troops in 1798 and 1799,[1369] and it became a priority of Muhammad Ali Pasha.[1370] The son of Muhammad Ali, Ismail Pasha, gave utmost importance to perennial irrigation. Under his rule, canals were dug to irrigate about 250 thousand acres (more than 100 thousand hectares) in the Upper Egypt. Also, the Fayum region irrigation was turned into perennial irrigation. In 1874, 1.75 million acres (more than 700 thousand hectares) were irrigated by the basin irrigation method and 3.5 million acres (about 1.5 million hectares) by the perennial irrigation throughout the Nile basin.[1371]

When the American Civil War caused a cessation of the cotton supplies to Europe from the American continent, the importance of the Egyptian cotton (the Turkestan cotton alike, see Chapter 5) increased. Between 1861 and 1863, cotton exports doubled from about 600 thousand *cantar*s to 1.28 million *cantar*s. The main markets for the Egyptian cotton were those in England, France, and Austria.[1372]

Water has occasionally been a source of political dispute throughout the history between the downstream and the upstream riparians in the Nile River basin, like it had been in the twelfth century between the Ethiopian king and the Egyptian Christians.[1373] Another example was from a nearer date, when Ismail Pasha annexed Darfur in 1875 and desired to take control of the Blue Nile River by defeating the

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Hanbury Brown, *The Delta Barrage of Lower Egypt* (Cairo: National Printing Department, 1902), pp.16-31; Samir Raafat, "The Delta Barrage," *Cairo Times*, 21 August 1997.

[1369] Hanbury Brown, *The Delta Barrage of Lower Egypt* (Cairo: National Printing Department, 1902), p.2.

[1370] Hanbury Brown, *The Delta Barrage of Lower Egypt* (Cairo: National Printing Department, 1902), pp.4-5.

[1371] W. Willcocks & James Craig, *Egyptian Irrigation* (London: Spon, 1913), p.302.

[1372] The New York Times, Egyptian Cotton: Its Modern Origin and the Importance of the Supply, 1864.

[1373] Goitom Gebreluel, "Ethiopia's Grand Renaissance Dam: Ending Africa's Oldest Geopolitical Rivalry?," *The Washington Quarterly*, vol. 37, no. 2, 2014, p.26.

emperor of Ethiopia, Yohannes IV. This aim he could not achieve as the Egyptian forces lost two consecutive battles at Gundet and Guta in 1875 and 1876.[1374] After a short while, the British invaded Egypt, together with the Sudan and Uganda, primarily for the British interests in the Suez Canal, but also, for controlling the Nile basin.[1375] One of the primary aims of the British in the Nile River basin was ensuring that the downstream Egypt gets more water, and thereby increasing the harvest of cotton.[1376]

Water was so important for the British administration in the Nile River that they signed a series of agreements with other colonial powers to regulate the Nile waters and to ensure that they do not interfere in the political economy of the Nile water management.[1377] An agreement was signed as early as in 1891 with Italy to restrict any construction on the Atbara River.[1378] In the late nineteenth century, the British authorities initiated expeditions towards the Sudd,[1379] and by 1902, Ethiopia was

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[1374] Ashok Swain, "Ethiopia, the Sudan, and Egypt: The Nile River Dispute," *The Journal of Modern African Studies*, vol. 35, no. 4, 1997, p.676.

[1375] Terje Tvedt, "About the Importance of Studying the Modern History of the Countries of the Nile Basin in a Nile Perspective," in T. Tvedt, ed. *The River Nile in the Post-Colonial Age: Conflict and Cooperation in the Nile Basin Countries*, 2010, p.3.

[1376] Terje Tvedt, "About the Importance of Studying the Modern History of the Countries of the Nile Basin in a Nile Perspective," in T. Tvedt, ed. *The River Nile in the Post-Colonial Age: Conflict and Cooperation in the Nile Basin Countries*, 2010, p.4.

[1377] Ashok Swain, "Ethiopia, the Sudan, and Egypt: The Nile River Dispute," *The Journal of Modern African Studies*, vol. 35, no. 4, 1997, p.676; Jutta Brunnée & Stephen Toope, "The Changing Nile Basin Regime: Does Law Matter?," *Harvard International Law Journal*, vol. 43, no. 1, 2002, p.106.

[1378] Jutta Brunnée & Stephen Toope, "The Changing Nile Basin Regime: Does Law Matter?," *Harvard International Law Journal*, vol. 43, no. 1, 2002, p.124; Wuhibegezer Ferede & Sheferawu Abebe, "The Efficacy of Water Treaties in the Eastern Nile Basin," *Africa Spectrum*, vol. 49, no. 1, 2014, p.58.

[1379] Robert Collins, "History, Hydropolitics and the Nile: Myth or Reality," in P.P. Howell & J.A. Allan, eds. *The Nile: Sharing a Scarce Resource - A Historical and Technical Review of Water Management and of Economical and Legal Issues*, 1994, pp.111-12.

prevented from initiating any water development projects on the Blue Nile.[1380] A similar treaty was signed with Congo in 1906 for the White Nile waters,[1381] and a tripartite treaty between France, Italy, and Britain was signed in the same year to protect Egyptian and British interest in the Nile River basin.[1382]

After the British seized Egypt in 1882 and made it a protectorate by the end of 1914 together with the Sudan,[1383] they made use of the numerous irrigation canals in Egypt. By the year 1912, in the Lower Egypt, there were several irrigation canals, some of which were: Ismailia, Sharkawia, Basusia, Rayah Tewfiki, Rayah Menufia, Mansuria, Rayah Abbas, Rayah Behera, Bahr Saidi, and Birimbal.[1384] In the beginning of the twentieth century, some noteworthy hydraulic works were the famous Aswan Dam and the Assiut Barrage designed by Willcocks and constructed by the British company, John Aird & Co. in 1902 and 1903, respectively. The Aswan Dam had a storage capacity of 1 cubic kilometers of water,[1385] and by 1910, 400 thousand acres (more than 160 thousand hectares) of lands were under irrigation through the canal systems around it.[1386] By the beginning of the twentieth century, the Nile

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[1380] Richard Paisley & Taylor Henshaw, "Transboundary Governance of the Nile River Basin: Past, Present and Future," *Environmental Development*, vol. 7, 2013, p.63; Wuhibegezer Ferede & Sheferawu Abebe, "The Efficacy of Water Treaties in the Eastern Nile Basin," *Africa Spectrum*, vol. 49, no. 1, 2014, pp.58-60.

[1381] Ashok Swain, "Ethiopia, the Sudan, and Egypt: The Nile River Dispute," *The Journal of Modern African Studies*, vol. 35, no. 4, 1997, pp.676-77.

[1382] Wuhibegezer Ferede & Sheferawu Abebe, "The Efficacy of Water Treaties in the Eastern Nile Basin," *Africa Spectrum*, vol. 49, no. 1, 2014, p.60.

[1383] Heather Hoag, *Developing the Rivers of East and West Africa: An Environmental History* (London: Bloomsbury, 2013), p.10.

[1384] W. Willcocks & James Craig, *Egyptian Irrigation* (London: Spon, 1913), p.410.

[1385] Hosam Elemam, "Egypt and Collective Action Mechanisms in the Nile Basin," in T. Tvedt, ed. *The River Nile in the Post-Colonial Age: Conflict and Cooperation among the Nile Basin Countries*, 2010, p.219.

[1386] By the 1910s, in general, a total of 1.3 million acres (more than 520 thousand hectares) of land were irrigated by basin irrigation methods, while 4.064 million acres (more than 1.6 million hectares) were irrigated by perennial methods. See: W. Willcocks & James Craig, *Egyptian Irrigation*

River delta was divided in three regions, which were irrigated by the canals that originating from the Delta Barrage. The western part of the Rosetta branch is mainly fed by Rayah Behera. The region between the Rosetta and the Damietta branches are irrigated by Rayah Menufia, and the region west of the Damietta is fed by the Rayah Tewfiki, the Ismailia, the Sharkawia and the Basusia.[1387]

Egyptian cotton became a strategic commodity for the British colonizers in a short while (Figure 7.2). Investments were intensified in the early 1900s with the Assiut Dam, or the Zefta Dam project completed in 1902.[1388] According to Sir William Garstin, then the Undersecretary of State for Public Works in Egypt, the Nile delta is the principal source of wealth in Egypt, and thus, this region must be given priority over other areas in the Nile valley, such as the fertile soils of the Sudan.[1389] This point of view explains the emergence of the Egyptian dominance in the Nile River basin hydropolitics in the twentieth century, sponsored by the British colonizers. By 1904, the British were handling the Nile as a single unit subject to river basin management.[1390] Thus, one may infer that the Nile River basin was one of the oldest river basin management examples in the world.

(London: Spon, 1913), pp.302-03. Of these lands, 964 thousand acres were in Upper Egypt, while 3.1 million acres were in Lower Egypt. See, p. 366.

[1387] Hanbury Brown, *The Delta Barrage of Lower Egypt* (Cairo: National Printing Department, 1902), p.26. This density of the canals were criticized by some contemporaries. See: W. Willcocks & James Craig, *Egyptian Irrigation* (London: Spon, 1913), pp.410-11.

[1388] W. Willcocks & James Craig, *Egyptian Irrigation* (London: Spon, 1913), p.302.

[1389] William Garstin, "Introduction," in R. Brown *The Delta Barrage of Lower Egypt*, 1902.

[1390] Rushdi Said, *The River Nile: Geology, Hydrology and Utilization* (Oxford: Pergamon Press, 1993), p.221; Terje Tvedt, "About the Importance of Studying the Modern History of the Countries of the Nile Basin in a Nile Perspective," in T. Tvedt, ed. *The River Nile in the Post-Colonial Age: Conflict and Cooperation in the Nile Basin Countries*, 2010, p.4.

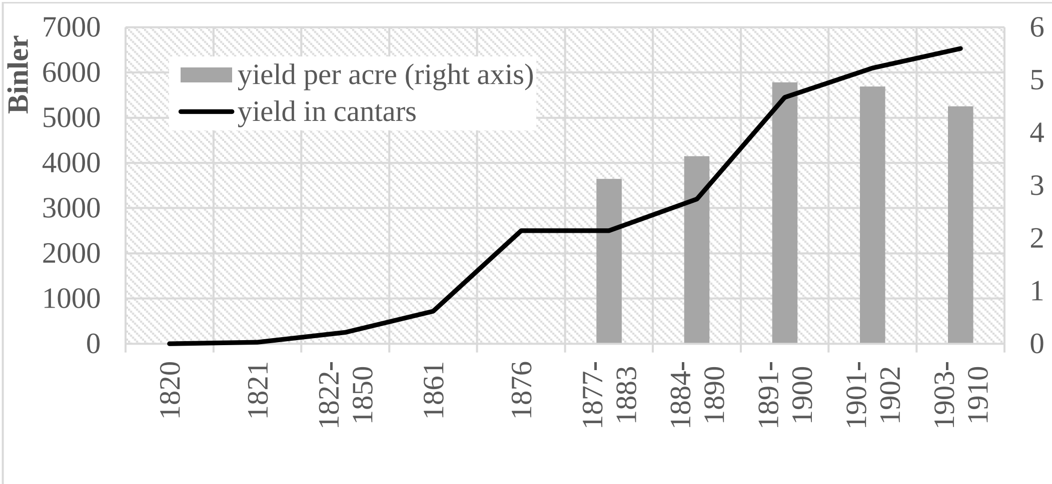

Figure 7.2. Cotton yield in the Nile River delta[1391]

7.3.2. The British legacy, power politics and water

The main principle of the Nile basin management of the British was limiting water development projects upstream and expanding cotton production as wide as possible.[1392] Like the water bureaucracy in the US contributed to the development of irrigation in the American West, the British water bureaucracy was influential in water development projects in Egypt. Some important planners were Sir William Garstin, Sir William Willcocks, and Sir Murdoch MacDonald.

Garstin was the adviser to the Ministry of Public Works of Egypt, and had grand plans for the Upper Nile basin, such as the 1904 Lake Tana project in Ethiopia,[1393]

[1391] W. Willcocks & James Craig, *Egyptian Irrigation* (London: Spon, 1913), p.411.

[1392] Terje Tvedt, "About the Importance of Studying the Modern History of the Countries of the Nile Basin in a Nile Perspective," in T. Tvedt, ed. *The River Nile in the Post-Colonial Age: Conflict and Cooperation in the Nile Basin Countries*, 2010, pp.4-5.

[1393] Nurit Kliot, *Water Resources and Conflict in the Middle East* (New York: Routledge, 1994), p.35.

in connection to the Lake Albert project, which, he foresaw, would serve as a natural reservoir to be controlled by the Egyptians.[1394] The famous Jonglei Canal project was also first proposed by Garstin, which could not be realized, but his proposal of Sennar Dam on the Blue Nile was accomplished.[1395] MacDonald, the successor of Garstin, had grand plans too, such as the Gebel Auliya, or the flood control facility at Naga Hammadi.[1396] The Sennar Dam project, initiated on the Blue Nile in the 1920s,[1397] was completed in 1925 and had a capacity of 0.93 cubic kilometers of water storage. The Gebel Auliya project on the White Nile, with a capacity of 3.5 cubic kilometers that became operational in 1937.[1398] While the former was built for irrigation of the cotton plantations[1399] and power generation, the latter was originally for river flow regulation[1400] and irrigation. Later on, hydroelectric generators were installed by Andritz Hydro to the latter dam.[1401] Willcocks (1852-1932) was an exceptional figure. He had a deep knowledge on and respect to indigenous knowledge and practices, in contrast to many of his contemporaries, and worked

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[1394] Rushdi Said, *The River Nile: Geology, Hydrology and Utilization* (Oxford: Pergamon Press, 1993), p.222.

[1395] Nurit Kliot, *Water Resources and Conflict in the Middle East* (New York: Routledge, 1994), p.35.

[1396] Rushdi Said, *The River Nile: Geology, Hydrology and Utilization* (Oxford: Pergamon Press, 1993), p.222.

[1397] Nurit Kliot, *Water Resources and Conflict in the Middle East* (New York: Routledge, 1994), p.35.

[1398] Fadwa Taha, "The History of the Nile Waters in the Sudan," in T. Tvedt, ed. *The River Nile in the Post-Colonial Age: Conflict and Cooperation among the Nile Basin Countries*, 2010, p.194.

[1399] Heather Hoag, *Developing the Rivers of East and West Africa: An Environmental History* (London: Bloomsbury, 2013), p.135.

[1400] Fadwa Taha, "The History of the Nile Waters in the Sudan," in T. Tvedt, ed. *The River Nile in the Post-Colonial Age: Conflict and Cooperation among the Nile Basin Countries*, 2010, p.194.

[1401] Andritz Hydro, *Hydromatrix: Jebel Aulia - Sudan*, Andritz Hydro GmbH, 2013, p.2.

until 1897 at the Egyptian irrigation service.[1402] He warned that due to the application of modern methods applied since the early nineteenth century instead of traditional irrigation methods, cotton yields may decrease.[1403]

Table 7-2. Cotton sown area in colonial Egypt[1404]

Year	Cotton sown area (acres)	Yield per acre (kilograms)
1895	1,000,000	5.27
1901	1,250,000	5.10
1906	1,500,000	4.61
1911	1,710,000	4.34

The British signed treaties and exchanged notes, which provided Egypt a privileged place in the use of the Nile waters. The 1929 Nile Waters Agreement between the

[1402] Heather Hoag, *Developing the Rivers of East and West Africa: An Environmental History* (London: Bloomsbury, 2013), pp.96-97.

[1403] W. Willcocks & James Craig, *Egyptian Irrigation* (London: Spon, 1913), p.411.

[1404] W. Willcocks & James Craig, *Egyptian Irrigation* (London: Spon, 1913), p.xxii.

Anglo-Egyptian Sudan and Egypt[1405] was a decent example.[1406] This agreement provided Egypt 48 cubic kilometers of water annually, and 4 cubic kilometers of water was given to the Sudan.[1407] Also, it restricted the Sudan from building dams on the Nile, in order to secure a steady water flow towards Egypt.[1408] For this purpose, in 1934, the storage capacity of the Aswan Dam was increased from 1 to 5 cubic kilometers.[1409]

As time passed by, the legitimacy of the Nile Waters Agreement began to be questioned as the upstream riparians, such as Uganda, began demanding water development projects on its territory. These requests found response in 1949 when notes were exchanged between the governments of Britain and Egypt regarding the construction of the Owen Falls Dam.[1410] The construction of this dam with an HPP, the largest British project in the East Africa, was finished in 1954, with 150 megawatts

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[1405] International Water Law Project, "Exchange of Notes between Her Majesty's Government in the United Kingdom and the Egyptian Government on the Use of Waters of the Nile for Irrigation," *International Water Law Project*, 1929, available at: http://www.internationalwaterlaw.org/documents/regionaldocs/Egypt_UK_Nile_Agreement-1929.html (accessed 11 March 2017).

[1406] Pierre Crabitès, "The Nile Waters Agreement," *Foreign Affairs*, 1929, available at: https://www.foreignaffairs.com/articles/sudan/1929-10-01/nile-waters-agreement (accessed 11 March 2017); Nurit Kliot, *Water Resources and Conflict in the Middle East* (New York: Routledge, 1994), pp.36-37.

[1407] Ashok Swain, "Ethiopia, the Sudan, and Egypt: The Nile River Dispute," *The Journal of Modern African Studies*, vol. 35, no. 4, 1997, p.677.

[1408] Jutta Brunnée & Stephen Toope, "The Changing Nile Basin Regime: Does Law Matter?," *Harvard International Law Journal*, vol. 43, no. 1, 2002, p.124.

[1409] Hosam Elemam, "Egypt and Collective Action Mechanisms in the Nile Basin," in T. Tvedt, ed. *The River Nile in the Post-Colonial Age: Conflict and Cooperation among the Nile Basin Countries*, 2010, p.219.

[1410] International Water Law Project, "Exchange of notes constituting an agreement between the Government of the United Kingdom of Great Britain and Northern Ireland and the Government of Egypt regarding the construction of the Owen Falls Dam," *International Water Law Project*, 1949, available at: http://www.internationalwaterlaw.org/documents/africa.html#Nile River Basin (accessed 11 March 2017).

of installed capacity.[1411] The British administration got the Tennessee Valley Authority of the US as an example for the Owen Falls project.[1412] To study the situation of the hydropower sector in the empire, in end-1917, the British government established the Water-Power Committee.[1413]

When the era of colonization ended in the 1950s, ten independent states were in the Nile River basin. The political atmosphere of independence after the 1952 revolution in Egypt both decentralized the river basin political administration and transformed water into a strategic resource for national development and economic growth. In this atmosphere, the Sudan, which became independent in 1956, and Egypt (under the name of the United Arab Republic) replaced the 1929 agreement with the Agreement for the Full Utilization of the Nile Waters in 1959. This agreement recognized the prior allocation of the 48 cubic kilometers of the Nile water to Egypt and 4 cubic kilometers to the Sudan as "established rights."[1414] Furthermore, the construction of some dams, such as the Sadd el-Aali, 6.5 kilometers upstream

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[1411] Heather Hoag, *Developing the Rivers of East and West Africa: An Environmental History* (London: Bloomsbury, 2013), p.143; Terje Tvedt, "About the Importance of Studying the Modern History of the Countries of the Nile Basin in a Nile Perspective," in T. Tvedt, ed. *The River Nile in the Post-Colonial Age: Conflict and Cooperation in the Nile Basin Countries*, 2010, p.5.

[1412] Heather Hoag, *Developing the Rivers of East and West Africa: An Environmental History* (London: Bloomsbury, 2013), p.125.

[1413] It is not easy to argue that the British were developed at hydroelectricity sector. According to a 1922 report of the Water-Power Committee, only about 8 percent of the world electricity capacity was installed within the British Empire (4,500 megawatts), including all the colonies. The hydroelectricity potential of the world was estimated at 52,000 megawatts, at that time. See: Heather Hoag, *Developing the Rivers of East and West Africa: An Environmental History* (London: Bloomsbury, 2013), p.129.

[1414] International Water Law Project, "Agreement (with Annexes) between the United Arab Republic and the Republic of Sudan for the full utilization of the Nile waters" 1959, available at: http://www.internationalwaterlaw.org/documents/regionaldocs/UAR_Sudan1959_and_Protocol1960.pdf (accessed 11 March 2017).

of the Aswan Dam,[1415] and the Roseires Dam on the Blue Nile[1416] would increase the amount of water allocated to the respective countries, 55.5 cubic kilometers to Egypt and 18.5 cubic kilometers to the Sudan.[1417]

The post-colonial era political atmosphere in Africa had some further impacts on water development projects. For example, the Sudan, in 1954, just before the independence, demanded a revision of the 1929 Nile Waters Agreement. The main demand of the Sudanese government was to accomplish the Roseires and the Gezira schemes.[1418] Ethiopia also raised voice for a possible modification of the 1929 Agreement and thus began challenging Egyptian dominance.[1419] The Sudanese authorities saw agriculture and irrigation crucial for a rapid economic development. After the signing of the 1959 Nile Waters Agreement, the Sudan began constructing the Khashm El Girba and the Roseires dams, and finished them in 1964 and 1966, respectively. The latter was built following a protocol signed with the World Bank

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[1415] International Bank for Reconstruction and Development, *Preliminary Report on the Sadd el-Aali Project*, International Bank for Reconstruction and Development, 1956.

[1416] International Water Law Project, "Agreement (with Annexes) between the United Arab Republic and the Republic of Sudan for the full utilization of the Nile waters" 1959, available at: http://www.internationalwaterlaw.org/documents/regionaldocs/UAR_Sudan1959_and_Protocol1960.pdf (accessed 11 March 2017).

[1417] Ashok Swain, "Ethiopia, the Sudan, and Egypt: The Nile River Dispute," *The Journal of Modern African Studies*, vol. 35, no. 4, 1997, p.679; International Water Law Project, "Agreement (with Annexes) between the United Arab Republic and the Republic of Sudan for the full utilization of the Nile waters" 1959, available at: http://www.internationalwaterlaw.org/documents/regionaldocs/UAR_Sudan1959_and_Protocol1960.pdf (accessed 11 March 2017).

[1418] Fadwa Taha, "The History of the Nile Waters in the Sudan," in T. Tvedt, ed. *The River Nile in the Post-Colonial Age: Conflict and Cooperation among the Nile Basin Countries*, 2010, p.188.

[1419] Rawia Tawfik, "Reconsidering counter-hegemonic dam projects: the case of the Grand Ethiopian Renaissance Dam," *Water Policy*, vol. 19, no. 1, 2016, p.4.

in 1961.[1420] Also with this agreement, the Jonglei Canal and the Aswan High Dam were initiated.[1421]

Before the revolution, the Egyptians were planning to build a higher dam at the site of the Aswan Dam.[1422] After the revolution, as Gamal Abdel Nasser, the second president of Egypt, positioned Egypt at a distance from the West, the World Bank and the US alike withdrew support from the Aswan High Dam project.[1423] As a result, the construction of the dam began leaning on the financial backing from the Soviet Union and funds generated by the now nationalized Suez Canal. The works began in 1960, and continued more than ten years, at a cost of 450 million British pounds (about one billion US dollars at that time). The dam became operational in 1971,[1424] and Nikita Khruschev paid a visit to the opening ceremony.[1425]

As the Egyptian government sought alliance with the Soviet Union, the Americans supported Ethiopia in accordance to the handbook of Cold War politics. In a short while, the USBR began an investigation of the Nile River basin.[1426] According to

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[1420] Fadwa Taha, "The History of the Nile Waters in the Sudan," in T. Tvedt, ed. *The River Nile in the Post-Colonial Age: Conflict and Cooperation among the Nile Basin Countries*, 2010, pp.192-95.

[1421] Jutta Brunnée & Stephen Toope, "The Changing Nile Basin Regime: Does Law Matter?," *Harvard International Law Journal*, vol. 43, no. 1, 2002, p.128.

[1422] Ashok Swain, "Ethiopia, the Sudan, and Egypt: The Nile River Dispute," *The Journal of Modern African Studies*, vol. 35, no. 4, 1997, p.680.

[1423] Asit Biswas, "Aswan Dam Revisited: The Benefits of a Much Maligned Dam," *Development and Cooperation*, vol. 6, 2002, p.25. The US informed Egypt on its withdrawal from the project with a letter dated July 19, 1956. See also: Ashok Swain, "Ethiopia, the Sudan, and Egypt: The Nile River Dispute," *The Journal of Modern African Studies*, vol. 35, no. 4, 1997, p.680.

[1424] History, "Aswan High Dam completed," *This Day in History*, 2017, available at: http://www.history.com/this-day-in-history/aswan-high-dam-completed (accessed 11 March 2017).

[1425] Asit Biswas, "Aswan Dam Revisited: The Benefits of a Much Maligned Dam," *Development and Cooperation*, vol. 6, 2002, p.25.

[1426] Rawia Tawfik, "Reconsidering counter-hegemonic dam projects: the case of the Grand Ethiopian Renaissance Dam," *Water Policy*, vol. 19, no. 1, 2016, p.4.

the 1961 *Annual Report of the Blue Nile River Basin Investigations*, the aims of the investigation project were "to inventory and report on the economic development of the resources of the Blue Nile River basin while at the same time assisting in establishing and training a water resources department capable of carrying on the work when the project is terminated."[1427] On various sites, dams and HPPs were planned to be built, noteworthy among which were: the Karadobi, the Mabil, the Mendaia, and the Border Dams.[1428] Further projects also appeared in the report, i.e. the Fato Diversion Dam on a tributary of the Blue Nile, the Guder River in Central Ethiopia, and the Fincha'a HPP on the Fincha River.[1429] Ethiopia's demand was a total of 6 cubic kilometers of water annually for irrigation purposes. [1430]

On the local level, Egypt and the Sudan were traditional allies since the colonial era, but Egypt has always been dominant in this hydropolitical relationship. It is true that water is shared between the countries with agreements, but the allocation of water is very unevenly despite some improvements achieved in favor of the Sudan by 1959 (Figure 7.1). Some points are necessary to note. First, Egypt has supported the HPP projects in the Sudan, as they do not seem to decrease the water amount received by Egyptian farmers on the one hand, and on the other, the reservoirs in the Sudan are beneficial for the maintenance of Egyptian reservoirs as

[1427] US Bureau of Reclamation, *Ethiopia-United States Cooperative Program for the Study of Water Resources*, The US Department of Interior, 1961, p.1. The USBR conducted fieldwork and collected data by setting up measuring stations on numerous locations with its 28 personnel along with 150 Ethiopians. See: pp.3-4.

[1428] Rawia Tawfik, "Reconsidering counter-hegemonic dam projects: the case of the Grand Ethiopian Renaissance Dam," *Water Policy*, vol. 19, no. 1, 2016, p.4.

[1429] US Bureau of Reclamation, *Ethiopia-United States Cooperative Program for the Study of Water Resources*, The US Department of Interior, 1961, pp.20-31. The 128 megawatts-capacity Fincha'a Dam and HPP was completed in 1973 and irrigated a total of 239.2 square kilometers of land. See: Bezuayehu Tefera & Geert Sterk, "Hydropower-Induced Land Use Change in Fincha'a Watershed, Western Ethiopia: Analysis and Impacts," *Mountain Research and Development*, vol. 28, no. 1, 2008, p.72 and 79.

[1430] Ashok Swain, "Ethiopia, the Sudan, and Egypt: The Nile River Dispute," *The Journal of Modern African Studies*, vol. 35, no. 4, 1997, p.680.

they trap huge loads of sediments before reaching the Lake Nasser. However, the irrigation schemes in the Sudan were strongly opposed by the Egyptian authorities.[1431] Second, as the downstream countries, Egypt and the Sudan, have been the main beneficiaries of the Nile waters,[1432] this shared interest converged their water policies. The two countries usually tend to defend their positions on their “historical rights” on the Nile waters against any upstream development projects.[1433] Third, the Sudan began raising voice against the Egyptian dominance and demanding higher water shares to exploit its high irrigation capacity.[1434] The Chinese and the Gulf capital helped the Sudan to develop some of its water potential in the 2000s, such as the Merowe Dam that was completed in 2009[1435] and the Roeseires Dam heightening projects.[1436] Currently, the Sudanese water use does not exceed its 18.5 cubic kilometers limit, but it is estimated that in the future, the limit would not be adequate for the demand originating from the Sudan.[1437] China supported not only the Sudan but also Ethiopia, Uganda, Burundi and Democratic

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[1431] Ashok Swain, "Ethiopia, the Sudan, and Egypt: The Nile River Dispute," *The Journal of Modern African Studies*, vol. 35, no. 4, 1997, p.686.

[1432] Richard Paisley & Taylor Henshaw, "Transboundary Governance of the Nile River Basin: Past, Present and Future," *Environmental Development*, vol. 7, 2013, p.64; Okbazghi Yohannes & Keren Yohannes, "Turmoil in the Nile River Basin: Back to the Future?," *Journal of Asian and African Studies*, vol. 48, no. 2, 2012, p.195.

[1433] Richard Paisley & Taylor Henshaw, "Transboundary Governance of the Nile River Basin: Past, Present and Future," *Environmental Development*, vol. 7, 2013, p.64.

[1434] Ana Cascão, "Changing Power Relations in the Nile River Basin: Unilateralism vs. Cooperation?," *Water Alternatives*, vol. 2, no. 2, 2009, p.257.

[1435] Ana Cascão, "Changing Power Relations in the Nile River Basin: Unilateralism vs. Cooperation?," *Water Alternatives*, vol. 2, no. 2, 2009, p.257.

[1436] China International Water and Electric Corp., "Water and Hydropower," 2017, available at: http://english.cwe.cn/show.aspx?id=1857&cid=22 (accessed 18 March 2017).

[1437] Ana Cascão, "Changing Power Relations in the Nile River Basin: Unilateralism vs. Cooperation?," *Water Alternatives*, vol. 2, no. 2, 2009, p.259.

Republic of Congo in their water development projects despite opposition of the Egyptian administration.[1438]

More recently, the political situation in the south of the Sudan has made the regional hydropolitics more complicated. As the South Sudan became independent, the South Sudanese government demanded a reassessment of the colonial-era treaties too. The Entebbe Agreement, signed at the Juba water summit in June 2013, was an example. All upstream countries, Ethiopia, Rwanda, Tanzania, Uganda, Kenya, and Burundi were signatories by 2013. Egypt, on the other hand, did not ratify the agreement and renounced its validity.[1439]

As the interests of the two downstream countries, Egypt and Sudan, coincided against Ethiopian challenge, these two countries occasionally backed each other politically. For instance, the Egyptian government aided the Sudanese government to remain in power in the 1970s and the Sudan acquiesced the Jonglei Canal project of Egypt.[1440] After the Derg (in power between 1974 and 1987) proclaimed Ethiopia as a Marxist-Leninist state, the relations between Egypt and Ethiopia further deteriorated. The Ethiopian government opposed the reclamation of the lands in the Sinai Peninsula with water pipelines under the Suez and announced that it would reduce the flow of the Blue Nile in retaliation. Egypt responded with threats of using military means.[1441]

[1438] Ana Cascão, "Changing Power Relations in the Nile River Basin: Unilateralism vs. Cooperation?," *Water Alternatives*, vol. 2, no. 2, 2009, p.261.

[1439] Aljazeera, "South Sudan set to sign new Nile agreement," *Aljazeera*, 2013, available at: http://www.aljazeera.com/news/africa/2013/06/201362075235645727.html (accessed 13 March 2017).

[1440] Ashok Swain, "Ethiopia, the Sudan, and Egypt: The Nile River Dispute," *The Journal of Modern African Studies*, vol. 35, no. 4, 1997, p.681.

[1441] Ashok Swain, "Ethiopia, the Sudan, and Egypt: The Nile River Dispute," *The Journal of Modern African Studies*, vol. 35, no. 4, 1997, p.687.

Under these circumstances, it is not surprising that in 1988, the State Minister of Foreign Affairs of Egypt speculated that "the next war in the Middle East would be over the Nile."[1442] In the same year, Ethiopia challenged Egyptian hegemony with its grand project, the Tana Beles Dam and HPP. The project would increase the hydroelectricity production and irrigate vast lands. The water would be taken from the Lake Tana to produce electricity and then discharged into the Beles River. This would affect the flow of the Blue Nile, and thus, Egypt blocked Ethiopian access to the African Development Bank loan for this project in 1990.[1443] The project would, then, turn into a small run-of-the-river HPP, and was opened in 2012. A more serious Ethiopian challenge would emerge in the years to come, as will be discussed in the following paragraphs.

7.3.3. Regional cooperation attempts

After the 1990s, Egypt altered its military threat strategy and embraced a more cooperative attitude towards the other riparians.[1444] Under the optimistic atmosphere in the world politics after the end of the Cold War, cooperation efforts in the Nile River basin gained pace,[1445] as water-related international legal arrangements continued in the early 1990s. First, the Sudan and Ethiopia signed a treaty in December 1991, and later, in July 1993, Egypt and Ethiopia signed another agreement.[1446] In late 1992, water ministers of the Nile basin countries met at Kampala and set up the

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[1442] Jutta Brunnée & Stephen Toope, "The Changing Nile Basin Regime: Does Law Matter?," *Harvard International Law Journal*, vol. 43, no. 1, 2002, p.106.

[1443] Jutta Brunnée & Stephen Toope, "The Changing Nile Basin Regime: Does Law Matter?," *Harvard International Law Journal*, vol. 43, no. 1, 2002, pp.127-28.

[1444] Terje Tvedt, "About the Importance of Studying the Modern History of the Countries of the Nile Basin in a Nile Perspective," in T. Tvedt, ed. *The River Nile in the Post-Colonial Age: Conflict and Cooperation in the Nile Basin Countries*, 2010, p.8.

[1445] Ashok Swain, "Challenges for Water Sharing in the Nile Basin: Changing Geo-Politics and Changing Climate," *Hydrological Sciences Journal*, vol. 56, no. 4, 2011.

[1446] Jutta Brunnée & Stephen Toope, "The Changing Nile Basin Regime: Does Law Matter?," *Harvard International Law Journal*, vol. 43, no. 1, 2002, p.106.

Technical Cooperation Committee for the Promotion of the Development and Environmental Protection of the Nile Basin. As Ethiopia and Kenya perceived Egypt as the dominant actor here, they refused to sign the agreement that established the committee.[1447] Though not directly related to water, in 1999, Kenya, Tanzania, and Uganda established the East African Community, to which Burundi and Rwanda joined in 2006. This international organization drafted the Lake Victoria Development Program and set up a commission in 2001 for coordinating efforts of this program.[1448]

A more significant development in the 1990s was the process of establishment of the Nile Basin Initiative, with the active encouragement of international organizations. The official aim of the initiative was announced as cooperatively developing the Nile basin. To achieve this aim, a "cooperative framework agreement" would be drafted by the initiative. This agreement would, later on, replace the bilateral agreements between the riparians.[1449] The political stability in the upstream riparians and the emergence of the international actors that aid upstream countries for their water development projects are major reasons why the Egyptian-dominated hydropolitics have been changing towards a cooperative multiparty regime in the Nile basin.[1450]

[1447] Richard Paisley & Taylor Henshaw, "Transboundary Governance of the Nile River Basin: Past, Present and Future," *Environmental Development*, vol. 7, 2013, p.65.

[1448] Ana Cascão, "Changing Power Relations in the Nile River Basin: Unilateralism vs. Cooperation?," *Water Alternatives*, vol. 2, no. 2, 2009, p.251.

[1449] Richard Paisley & Taylor Henshaw, "Transboundary Governance of the Nile River Basin: Past, Present and Future," *Environmental Development*, vol. 7, 2013, p.67.

[1450] Ana Cascão, "Changing Power Relations in the Nile River Basin: Unilateralism vs. Cooperation?," *Water Alternatives*, vol. 2, no. 2, 2009, pp.250-51.

As Yohannes and Yohannes note, in this decade, the discourse tended to shift from "water rights" to "benefit sharing" among the ten riparians.[1451] The Nile Basin Initiative was founded in 1999 and with the cooperative framework agreement, the establishment of the Nile Basin Commission was foreseen, which would have a permanent character, in order to jointly manage and develop water resources within the basin.[1452] In the early 2000s, significant hopes for cooperation in the Nile basin prevailed among the international community and among the authorities of the basin countries.[1453] For instance, Ethiopia got the consent of Egyptian and the Sudanese governments for the Karadobi, the Mandaia, and the Border Dams in the early 2000s and applied the Nile Basin Initiative for securing international financial support.[1454]

Serious gains were made during the negotiations of the cooperative framework agreement. Yet, later on, the traditional historical split between the upstream and downstream resurfaced. Egypt initiated vast projects for irrigation of millions of hectares of land without consulting the other riparians. In May 2010, Ethiopia, Kenya, Rwanda, Tanzania, and Uganda contracted the Nile Cooperative Framework Agreement to found the NBI. This step was perceived to be against the Egyptian and the Sudanese demands and pressures on water issues.[1455] As the

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[1451] Okbazghi Yohannes & Keren Yohannes, "Turmoil in the Nile River Basin: Back to the Future?," *Journal of Asian and African Studies*, vol. 48, no. 2, 2012, p.202.

[1452] Okbazghi Yohannes & Keren Yohannes, "Turmoil in the Nile River Basin: Back to the Future?," *Journal of Asian and African Studies*, vol. 48, no. 2, 2012, p.202; Nile Basin Initiative, "Cooperative Framework Agreement," *Nilebasin.org*, 2017, available at: http://nilebasin.org/index.php/new-and-events/105-nile-basin-initiative-launches-new-partnership-with-power-africa (accessed 12 April 2017).

[1453] Jutta Brunnée & Stephen Toope, "The Changing Nile Basin Regime: Does Law Matter?," *Harvard International Law Journal*, vol. 43, no. 1, 2002, p.108.

[1454] Rawia Tawfik, "Reconsidering counter-hegemonic dam projects: the case of the Grand Ethiopian Renaissance Dam," *Water Policy*, vol. 19, no. 1, 2016, p.4.

[1455] Okbazghi Yohannes & Keren Yohannes, "Turmoil in the Nile River Basin: Back to the Future?," *Journal of Asian and African Studies*, vol. 48, no. 2, 2012, pp.203-04.

deteriorating relations in the 2010s damaged the cooperative atmosphere, in 2011, the Ethiopian government announced the initiation of the Grand Ethiopian Renaissance Dam.

7.3.4. The Grand Ethiopian Renaissance Dam

Parkes argues that the dominance of Egypt in the basin is the very source of water insecurity in the Nile basin.[1456] But as some scholars observe, the dominant riparian position of Egypt is changing. Some argue that Egypt's power is not unchallengeable and the surprising[1457] announcement of the Grand Ethiopian Renaissance Dam project by the Ethiopian government is an open challenge in that respect.[1458] Some authors argue that the geopolitics in the Nile River basin has been altering due to the state-formation process of Ethiopia, and this would undermine Egyptian hydro-hegemony to a significant degree.[1459]

The Ethiopian government announced the inception of the Grand Ethiopian Renaissance Dam under the politically uncertain atmosphere caused by the Arab spring, as argued by some authors.[1460] The construction of the dam would increase water

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[1456] Laura Parkes, "The Politics of 'Water Scarcity' in the Nile Basin: the Case of Egypt," *Journal of Politics & International Studies*, vol. 9, 2013, p.437.

[1457] Goitom Gebreluel, "Ethiopia's Grand Renaissance Dam: Ending Africa's Oldest Geopolitical Rivalry?," *The Washington Quarterly*, vol. 37, no. 2, 2014, p.25.

[1458] Ana Cascao, "Ethiopia–Challenges to Egyptian hegemony in the Nile Basin," *Water Policy*, vol. 10, no. Supplement 2, 2008; Filippo Menga, "Hydropolis: Reinterpreting the Polis in Water Politics," *Political Geography*, vol. 60, 2017, p.104.

[1459] Goitom Gebreluel, "Ethiopia's Grand Renaissance Dam: Ending Africa's Oldest Geopolitical Rivalry?," *The Washington Quarterly*, vol. 37, no. 2, 2014, p.26; Rawia Tawfik, "Reconsidering counter-hegemonic dam projects: the case of the Grand Ethiopian Renaissance Dam," *Water Policy*, vol. 19, no. 1, 2016, p.7.

[1460] Filippo Menga, "Hydropolis: Reinterpreting the Polis in Water Politics," *Political Geography*, vol. 60, 2017, p.104; Fred Pearce, "On the River Nile, a Move to Avert a Conflict Over Water," *Yale Environment 360*, 2015, available at: http://e360.yale.edu/features/on_the_river_nile_a_move_to_avert_a_conflict_over_water (accessed 13 March 2017); Rawia Tawfik, "Reconsidering counter-hegemonic dam projects: the case of the Grand Ethiopian Renaissance Dam," *Water Policy*, vol. 19, no. 1, 2016, p.7.

stress in Egypt according to Egyptian experts,[1461] although recent analyses challenge this view.[1462] The impact would depend, first, on the filling time, and after the reservoir is filled, it will depend on the purpose of water use stored in the reservoir. If it would be used solely for hydropower generation as claimed by the Ethiopian authorities, then the amount received by Egypt would be impacted less. However, if irrigation is also a part of the picture, then the released water towards Egypt would decline.[1463] Actually, the hydropower planned to be produced by the dam and other development projects would bring an additional benefit of 2.8 to 3.6 billion US dollars to the countries in the basin, along with additional benefits of flood control and increased irrigation opportunities.[1464] For example, it may help the Sudanese authorities controlling floods. Also, the stored water in the reservoir of the dam may be used by the farmers in Sudan. This means that Sudan may be able to use more water from the Nile than it was entitled by the 1959 Agreement.[1465]

To investigate the real impacts of the dam, the governments of Egypt, Ethiopia and the Sudan established a committee of ten members, four of which being interna-

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[1461] Nadia Abdelsalam, Medhat Aziz & Asmaa Agrama, "Quantitative and Financial Impacts of Nile River Inflow Reduction on Hydropower and Irrigation in Egypt," *Energy Procedia*, vol. 50, 2004, p.653; The Economist, "Sharing the Nile," *The Economist*, 2016, available at: https://www.economist.com/news/middle-east-and-africa/21688360-largest-hydroelectric-project-africa-has-so-far-produced-only-discord-egypt (accessed 8 September 2017).

[1462] See, for example: Marc Jeuland, Xun Wu & Dale Whittington, "Infrastructure Development and the Economics of Cooperation in the Eastern Nile," *Water International*, vol. 42, no. 2, 2017; Diane Arjoon, Yasir Mohamed, Quentin Goor & Amaury Tilmant, "Hydro-Economic Risk Assessment in the Eastern Nile River Basin," *Water Resources and Economics*, vol. 8, 2014.

[1463] The Economist, "Sharing the Nile," *The Economist*, 2016, available at: https://www.economist.com/news/middle-east-and-africa/21688360-largest-hydroelectric-project-africa-has-so-far-produced-only-discord-egypt (accessed 8 September 2017).

[1464] Diane Arjoon, Yasir Mohamed, Quentin Goor & Amaury Tilmant, "Hydro-Economic Risk Assessment in the Eastern Nile River Basin," *Water Resources and Economics*, vol. 8, 2014, p.17 and 28.

[1465] Marc Jeuland, Xun Wu & Dale Whittington, "Infrastructure Development and the Economics of Cooperation in the Eastern Nile," *Water International*, vol. 42, no. 2, 2017, p.124.

tional. The committee finalized its report in May 2013 and submitted it to the respective governments.[1466] According to the report, “the water supply in Egypt will not be affected during the first filling of the [Grand Ethiopian Renaissance Dam], given wet or average years, although power generation at the [Aswan High Dam] will be decreased by about 6 [percent] due to the general lower water levels in Lake Nasser.”[1467] Also, the committee found that the dam would increase the regulation and hydropower generation capacity in the river basin.[1468]

The Grand Ethiopian Renaissance Dam is planned to be 145-175 meters tall and store about 75 cubic kilometers of water. This corresponds to an amount 13 times Ethiopian water consumption.[1469] With this volume of its reservoir, it will rank among the top ten largest reservoirs in the world, just behind the Aswan High Dam.

[1466] International Panel of Experts on Grand Ethiopian Renaissance Dam Project, *Final Report*, 2013, available at: http://www.scidev.net/filemanager/root/site_assets/docs/international_panel_of_experts_for_ethiopian_renaissance_dam-_final_report.pdf (accessed 9 November 2017), p.1.

[1467] International Panel of Experts on Grand Ethiopian Renaissance Dam Project, *Final Report*, 2013, available at: http://www.scidev.net/filemanager/root/site_assets/docs/international_panel_of_experts_for_ethiopian_renaissance_dam-_final_report.pdf (accessed 9 November 2017), p.36.

[1468] International Panel of Experts on Grand Ethiopian Renaissance Dam Project, *Final Report*, 2013, available at: http://www.scidev.net/filemanager/root/site_assets/docs/international_panel_of_experts_for_ethiopian_renaissance_dam-_final_report.pdf (accessed 9 November 2017), p.36.

[1469] SciDev, "Africa’s hydropower future," *SciDev.Net*, 2014, available at: http://www.scidev.net/global/energy/data-visualisation/africa-hydropower-future-interactive.html#section-5 (accessed 9 September 2017); Filippo Menga, "Hydropolis: Reinterpreting the Polis in Water Politics," *Political Geography*, vol. 60, 2017, p.104. Note that Menga gives the storage volume as 10 cubic kilometer, which actually is the volume of the main dam. See: Salini Impreglio, "Grand Ethiopian Renaissance Dam Project," 2014, available at: https://www.salini-impregilo.com/en/projects/in-progress/dams-hydroelectric-plants-hydraulic-works/grand-ethiopian-renaissance-dam-project.html (accessed 9 September 2017). See also: Getachew Nigatu & Ariel Dinar, "Economic and Hydrological Impacts of the Grand Ethiopian Renaissance Dam on the Eastern Nile River Basin," *Environment and Development Economics*, vol. 21, no. 4, 2015, p.532.

As discussed above, the USBR has proposed some projects in the 1960s. The storage and installed power generating capacity of the Grand Ethiopian Renaissance Dam far exceed the four dams proposed earlier by the USBR.[1470]

The filling of this storage is foreseen to take three years. However, Egyptian authorities demand the filling time continue for at least ten years in order to receive highest possible amount of water.[1471] Jeuland et al. argue that the main reason behind the Egyptian opposition to the Grand Ethiopian Renaissance Dam is a hydrological uncertainty. After the reservoir is filled, the Egyptian authorities may never know if the flow regime would be altered in the future because of the way the water is managed by the Ethiopian authorities. This also means that Ethiopia will always hold a card against Egyptian hydro-hegemony.[1472] This is interpreted by Whittington et al. as a misunderstanding of the dam-related risks by the Egyptian authorities. The authors argue that the building of the Ethiopian dam may well benefit all the concerned parties, including Egypt, the Sudan and Ethiopia, if the governments choose a more cooperative path.[1473] Arjoon et al. have similar views and argue that cooperation between the Sudan, Egypt and Ethiopia would generate greater benefits than conflictual engagement between the upstream and the downstream countries.[1474] On the other hand, some authors argue that a comprehensive agreement in the basin does not seem possible as the upstream and downstream countries pursue

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[1470] Rawia Tawfik, "Reconsidering counter-hegemonic dam projects: the case of the Grand Ethiopian Renaissance Dam," *Water Policy*, vol. 19, no. 1, 2016, p.4.

[1471] Fred Oluoch, "Nile Basin countries building bridges over Ethiopian dam, to calm tensions," *The EastAfrican*, 2017, available at: http://www.theeastafrican.co.ke/news/Nile-Basin-countries-building-bridges-over-Ethiopian-dam/2558-3843492-lc421n/index.html (accessed 8 September 2017).

[1472] Marc Jeuland, Xun Wu & Dale Whittington, "Infrastructure Development and the Economics of Cooperation in the Eastern Nile," *Water International*, vol. 42, no. 2, 2017, p.123.

[1473] Dale Whittington, John Waterbury & Marc Jeuland, "The Grand Renaissance Dam and prospects for cooperation on the Eastern Nile," *Water Policy*, vol. 16, no. 4, 2014.

[1474] Diane Arjoon, Yasir Mohamed, Quentin Goor & Amaury Tilmant, "Hydro-Economic Risk Assessment in the Eastern Nile River Basin," *Water Resources and Economics*, vol. 8, 2014, p.28.

self-interest policies. As an alternative, allocation of water rights through an institution, such as the NBI, is proposed.[1475]

7.3.5. The Aswan issue

One of the most important water structures in Egypt is the Aswan, or the Aswan High Dam. It is located at 7 kilometers distance to the Aswan city, on the Nile. The High Dam replaced the old and smaller dam at about the same location. The construction continued between 1960 and 1967, and ended up with a dam of 360 meters crest length and 111 meters height. The reservoir has more than 160 cubic kilometers water capacity and is about 500 kilometers long, extending towards the Sudanese territory.[1476] With this volume, it is among the top ten largest reservoirs in the world. It is followed, however, by another great reservoir, the one behind the Grand Ethiopian Renaissance Dam.

The Aswan High Dam has long been on the agenda of global water policy circles. The main reason behind this, as mentioned in the previous section, is that it became subject to the Cold War politics between the Soviet Union and the US.[1477] Many negative comments on the Aswan Dam appeared in the literature during the Cold War by the academicians under the Cold War atmosphere of political rivalry, as well as under the enthusiastic atmosphere of the newly emerging environmental movement at that time, especially in the US. The importance of the dam was that it

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[1475] Getachew Nigatu & Ariel Dinar, "Economic and Hydrological Impacts of the Grand Ethiopian Renaissance Dam on the Eastern Nile River Basin," *Environment and Development Economics*, vol. 21, no. 4, 2015, p.533.

[1476] Nile Basin Initiative, *Review of Hydropower Multipurpose Project Coordination Regimes*, NBI, 2008, available at: http://nileis.nilebasin.org/system/files/NBI_%20Best%20Practice%20Compendium_Final.pdf (accessed 12 April 2017), p.46; Ashok Swain, "Challenges for Water Sharing in the Nile Basin: Changing Geo-Politics and Changing Climate," *Hydrological Sciences Journal*, vol. 56, no. 4, 2011, p.690.

[1477] Asit Biswas, "Aswan Dam Revisited: The Benefits of a Much Maligned Dam," *Development and Cooperation*, vol. 6, 2002, p.25.

was the first and foremost project supported by the Soviet Union outside of its political sphere of influence in the North Africa.[1478] Biswas argues that most of the current knowledge based on the academic studies published during the Cold War years are politically biased, and contrary to common belief, the dam has had several benefits to the Egyptian people. The initial cost of the project was recovered quickly from the additional revenues of hydropower generation and increased agricultural production.[1479]

On the other hand, it is reported by observers as early as in 1978 that a number of "side effects" have emerged since the completion of the high dam.[1480] In the 1990s, the amount of water accumulated in the dam was so high that the excess amount had to be drained. A canal with the name of Toshka Canal was planned to be built for this purpose. The drainage works were completed in the late 1990s and led to the establishment of the so called Toshka Lakes.[1481] Together with this drainage project the irrigation scheme under the name of the "New Valley" resurfaced, which had been shelved during Nasser era.[1482] This project is supported with the 52 kilo-

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[1478] Asit Biswas, "Aswan Dam Revisited: The Benefits of a Much Maligned Dam," *Development and Cooperation*, vol. 6, 2002, p.26.

[1479] Asit Biswas, "Aswan Dam Revisited: The Benefits of a Much Maligned Dam," *Development and Cooperation*, vol. 6, 2002, p.26.

[1480] Thomas Lippman, "Excess Water Is a Problem As Aswan Dam Tames Nile," *The Washington Post*, 1978, available at: https://www.washingtonpost.com/archive/opinions/1978/11/12/excess-water-is-a-problem-as-aswan-dam-tames-nile/cb2e579e-0e48-43de-a2ec-6c2396a9f3af/?utm_term=.b881c6fe25f0 (accessed 8 September 2017).

[1481] Gamal El-Shabrawy & Henri Dumont, "The Toshka Lakes," in H.J. Dumont, ed. *The Nile: Monographiae Biologicae*, 2009.

[1482] Emmarie Deputy, *Designed to Deceive : President Hosni Mubarak's Toshka Project*, The University of Texas at Austin, 2011, available at: http://hdl.handle.net/2152/ETD-UT-2011-05-3121 (accessed 8 September 2017), p.1.

meters long Sheikh Zayed Canal, built between 1997 and 2002, and with the Mubarak Pumping Station,[1483] completed in 2005 as one of the biggest pumping stations globally.[1484]

With the New Valley (or Toshka) Project, the Egyptian leader Gamal Abdel Nasser, and later on, Hosni Mubarak, planned to irrigate about 2,000 square kilometers of desert land and foresaw to move about 20 percent of the Egyptian population to this newly manmade oasis, with the slogan of "march to the desert."[1485] However, the soil salinity, together with economic hardships and political mismanagement made the completion of the project even harder. Only 210 square kilometers of farmland could be developed, instead of the planned 2,000 square kilometers, and the new employment expectations were not met.[1486] Deputy argues that despite its proven non-feasibility, the project was continued by Mubarak in order to benefit from it politically.[1487] The years in which the project was initiated were relatively humid. The 2010s, however, witnessed a severe drought in Africa affecting about 20 million people, as in many other regions of the world, such as the West America, as

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[1483] Gamal El-Shabrawy & Henri Dumont, "The Toshka Lakes," in H.J. Dumont, ed. *The Nile: Monographiae Biologicae*, 2009, p.158.

[1484] Bradley Hope, "Egypt's New Nile Valley: Grand Plan Gone Bad," *The National*, 2012, available at: https://www.thenational.ae/world/mena/egypt-s-new-nile-valley-grand-plan-gone-bad-1.402214 (accessed 9 September 2017).

[1485] Soraya Nelson, "Mubarak's Dream Remains Just That In Egypt's Desert," *npr*, 2012, available at: http://www.npr.org/2012/07/10/155027725/mubaraks-dream-remains-just-that-in-egypts-desert (accessed 9 September 2017).

[1486] Bradley Hope, "Egypt's New Nile Valley: Grand Plan Gone Bad," *The National*, 2012, available at: https://www.thenational.ae/world/mena/egypt-s-new-nile-valley-grand-plan-gone-bad-1.402214 (accessed 9 September 2017).

[1487] Emmarie Deputy, *Designed to Deceive : President Hosni Mubarak's Toshka Project*, The University of Texas at Austin, 2011, available at: http://hdl.handle.net/2152/ETD-UT-2011-05-3121 (accessed 8 September 2017).

mentioned above.[1488] The drought situation led the Ministry of Water Resources of Egypt declare a state of emergency in 2016. The government banned rice growing, a crop that needs huge amounts of water for harvesting.[1489]

Climate change augments the problems in the Nile River basin by influencing water resources availability in the basin. The impact is estimated to be heavier in the arid zones downstream. Some studies found that by 2050, the Nile flow in Egypt would be 15 percent less than in 2014, due to the impacts of the climate change and due to an increase in water consumption upstream. Besides the decrease in the level of water quantity, the volatility of water flows and increased evaporation in the huge reservoirs, such as the Lake Nasser pose a great risk of sustainability to Egypt.[1490]

In general, it is observed that the flow of the Nile River, measured at Aswan, has decreased significantly during the course of the twentieth century. By the beginning of the 2000s, only 2 percent of the Nile water reached to the Mediterranean Sea. This had some negative consequences on the ecological balance,[1491] along with other problems, such as pollution and salinization. Pollution is a major problem in the Nile River basin, and Egypt has been the most impacted because of its down-

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[1488] Ismail Akwei, "Reality of the worst drought since 1945 peaking in parts of Africa," *Africanews*, 2017, available at: http://www.africanews.com/2017/03/17/depth-of-the-worst-drought-since-1945-peaking-in-parts-of-africa// (accessed 9 September 2017).

[1489] Walaa Hussein, "How Egypt plans to address its growing water crisis," *Al Monitor*, 2016, available at: http://www.al-monitor.com/pulse/en/originals/2016/06/egypt-crops-water-crisis-state-emergency.html (accessed 9 September 2017).

[1490] Nadia Abdelsalam, Medhat Aziz & Asmaa Agrama, "Quantitative and Financial Impacts of Nile River Inflow Reduction on Hydropower and Irrigation in Egypt," *Energy Procedia*, vol. 50, 2004, p.653.

[1491] Jutta Brunnée & Stephen Toope, "The Changing Nile Basin Regime: Does Law Matter?," *Harvard International Law Journal*, vol. 43, no. 1, 2002, pp.117-18.

stream location and its high dependence on the Nile. Agricultural activities are crucial here as the main reason for the pollution is the use of pesticides in farming sector. Domestic and industrial wastewater further exacerbate the problems.[1492]

7.3.6. Agriculture and irrigation

Water is a scarce resource in Egypt, the total water resources of which is estimated at 67 cubic kilometers per year. The ultimate source is the Nile River, with about 55.5 cubic kilometers of water is contributed by the river. About 9 cubic kilometers of water is provided by the drainage and wastewater reuse, 2.7 cubic kilometers by groundwater and only 0.3 cubic kilometers from the precipitation.[1493]

In the Nile River basin, the downstream countries, Egypt and the Sudan, have long been the main beneficiaries of the Nile waters.[1494] Actually, throughout the Nile basin, 85 percent of the blue water consumption belongs to agricultural activity. Irrigation is dense in all downstream countries, and 97 percent of total irrigated agriculture is conducted in the Sudan and Egypt.[1495]

[1492] Jutta Brunnée & Stephen Toope, "The Changing Nile Basin Regime: Does Law Matter?," *Harvard International Law Journal*, vol. 43, no. 1, 2002, p.119.

[1493] Nadia Abdelsalam, Medhat Aziz & Asmaa Agrama, "Quantitative and Financial Impacts of Nile River Inflow Reduction on Hydropower and Irrigation in Egypt," *Energy Procedia*, vol. 50, 2004, p.654.

[1494] Richard Paisley & Taylor Henshaw, "Transboundary Governance of the Nile River Basin: Past, Present and Future," *Environmental Development*, vol. 7, 2013, p.64; Okbazghi Yohannes & Keren Yohannes, "Turmoil in the Nile River Basin: Back to the Future?," *Journal of Asian and African Studies*, vol. 48, no. 2, 2012, p.195.

[1495] Reem Digna, et al., "Nile River Basin Modelling for Water Resources Management – A Literature Review," *International Journal of River Basin Management*, vol. 15, no. 1, 2017, p.42.

Table 7-3. Irrigation and hydropower potential of the Nile basin countries[1496]

	Irrigation Potential (thousand hectares)	Irrigated lands (thou-sand hectares)	Hydropower Potential (megawatts)	Installed capacity (megawatts)
Burundi	80	0.05	20	0
Congo	10	0.08	78	0
Egypt	4,420	2,923 - 3,324	2,902	2,862
Eritrea	150	5.8	N/A	N/A
Ethiopia	2,220	15.9 - 32.1	17,355	1,946
Kenya	180	5.6 - 9.8	216	25
Rwanda	150	3.3 - 5.0	47	27
South Sudan	N/A	N/A	2,570	0
Sudan	4,843	1,946 - 2,176	4,873	1,593
Tanzania	30	0.5 - 14.1	280	0
Uganda	202	9.1 - 25.1	4,723	380

As Jeuland et al. argue, there is already a significant gap between water demand and supply in the Nile River basin. As the riparian governments have plans for further developing their irrigated agriculture, there is the risk that this gap widens even further. According to the authors, the Sudan possesses about 39 percent of the total irrigable lands in the Nile River basin, while Egypt and Ethiopia possess 36 and 18 percent, respectively. On the other hand, Egypt has 59 percent of the total irrigated lands in the region with about two-thirds of its potential already harnessed. Sudan has 39 percent of the total irrigated lands, while the remaining 2 percent is scattered among the other riparians, including Ethiopia (Table 7-3).

1496 Based on: Marc Jeuland, Xun Wu & Dale Whittington, "Infrastructure Development and the Economics of Cooperation in the Eastern Nile," *Water International*, vol. 42, no. 2, 2017, p.123; Dagmawi Degefu & Weijun He, "Water Bankruptcy in the Mighty Nile River Basin," *Sustainable Water Resources Management*, vol. 2, no. 1, 2016, p.34.

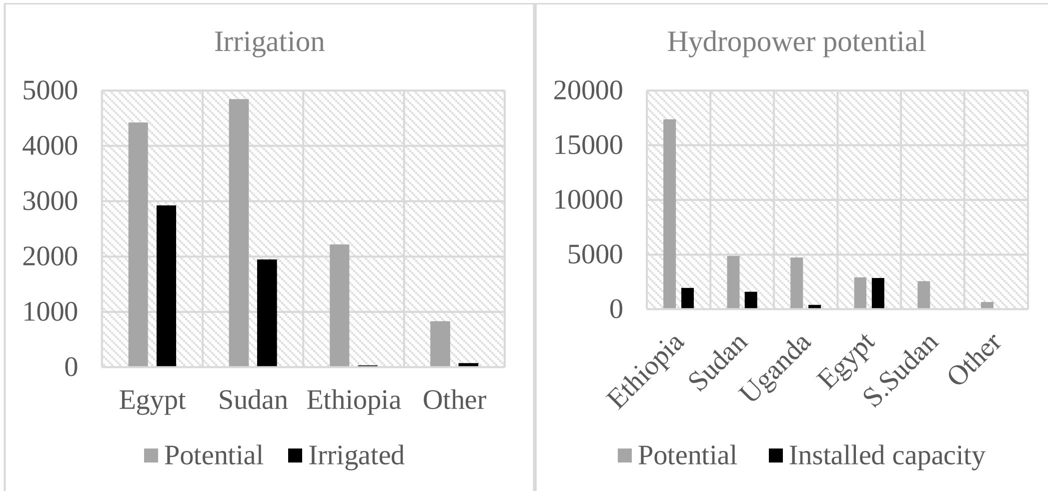

Figure 7.3. Irrigation and hydropower potential in the Nile River basin[1497]

On the other hand, Egyptian geography has some definitive characteristics that decrease the efficiency in irrigation. First, the aridity and the desert climate, as mentioned in the first section of this chapter, cause water being lost through evaporation in the long distances between the water storage and the fields.[1498] The Nile water flows through one of the driest and most arid regions in the world, especially downstream of Ethiopia. Whittington et al. estimate that about 40 percent of water evaporates between the Lake Tana in Ethiopia and its mouth at the Mediterranean coast.[1499] Second, the flat plains of Egypt necessitates water traveling long distances in low velocity. Keller et al. found that the travel duration of water from the

[1497] Irrigation potential in thousand hectares; hydropower potential in megawatts. Based on: Marc Jeuland, Xun Wu & Dale Whittington, "Infrastructure Development and the Economics of Cooperation in the Eastern Nile," *Water International*, vol. 42, no. 2, 2017, p.123.

[1498] Dale Whittington, Xun Wu & Claudia Sadoff, "Water Resources Management in the Nile Basin: The Economic Value of Cooperation," *Water Policy*, vol. 7, no. 3, 2005, p.9.

[1499] Dale Whittington, Xun Wu & Claudia Sadoff, "Water Resources Management in the Nile Basin: The Economic Value of Cooperation," *Water Policy*, vol. 7, no. 3, 2005, p.9.

Aswan High Dam to the fields in the Nile Delta is about 10 days.[1500] These characteristics have an impact on the increase in the volume of irrigation water in Egypt.

As stated above, the Nile River is the only source of agriculture and freshwater for most of the Egyptians. The freshwater is diverted through the canals (Figure 7.5), whose length reach 40 thousand kilometers,[1501] and the efficiency of this canal system is subject to debate, as mentioned above. As a strategy of reducing this inefficiency, the Egyptian governments tried to reduce irrigated agriculture. For instance, with the support and encouragement of the US, the country abandoned its policy of food self-sufficiency since the 1970s.[1502] Although the share of agriculture in the gross domestic product has declined beginning from the early 1970s, total agricultural activity has steadily increased in the second half of the century, in constant US dollar terms (Figure 7.4). As the growth in population and economy seems to continue, agricultural water demand is estimated to increase in the long term.[1503] The high dependence on irrigated agriculture necessitated high amounts of investments in the irrigation networks. The governments spent most of the World Bank credits for investing in agricultural sector until 1992.[1504]

[1500] A. Keller, R. Sakthivadivel & D. Seckler, "Water scarcity and the role of storage in development," 2000, available at: http://iwmi.cgiar.org/publications/iwmi_research_reports/pdf/pub039/report39.pdf (accessed 30 Augustus 2017), p.8.

[1501] Food and Agriculture Organization of the United Nations, "Egypt: Water Resources," *Aquastat*, 2016, available at: http://www.fao.org/nr/water/aquastat/countries_regions/Profile_segments/EGY-WR_eng.stm (accessed 10 September 2017).

[1502] Jutta Brunnée & Stephen Toope, "The Changing Nile Basin Regime: Does Law Matter?," *Harvard International Law Journal*, vol. 43, no. 1, 2002, p.120.

[1503] Nadia Abdelsalam, Medhat Aziz & Asmaa Agrama, "Quantitative and Financial Impacts of Nile River Inflow Reduction on Hydropower and Irrigation in Egypt," *Energy Procedia*, vol. 50, 2004, p.653.

[1504] Jutta Brunnée & Stephen Toope, "The Changing Nile Basin Regime: Does Law Matter?," *Harvard International Law Journal*, vol. 43, no. 1, 2002, p.121.

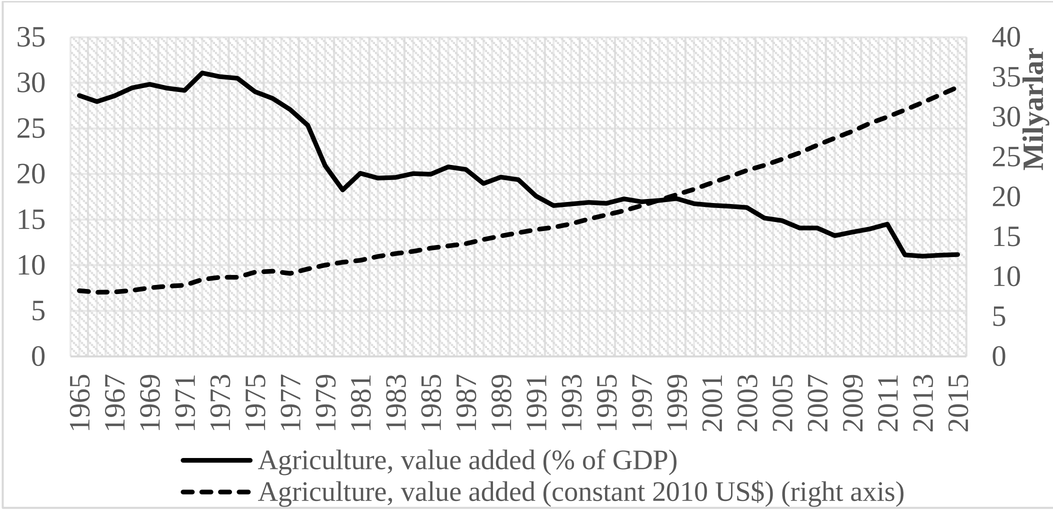

Figure 7.4. Agricultural activity in Egypt[1505]

There are some major "economic pressures" that determine the characteristic of the upstream-downstream dispute in the Nile River basin. First, it is economically more appropriate to store and withdraw irrigation water upstream rather than downstream, due to evaporation losses mentioned above. On the other hand, another pressure dictates withdrawing irrigation water as downstream as possible to let the water flow through as many HPP facilities as possible during its journey. Whittington et al. calculated that the volume of the Blue Nile peaks near the Ethiopia-Sudan border, around the site where the Grand Ethiopian Renaissance Dam is constructed. Thus, the economic value of generated hydroelectricity is highest at the border.[1506] Actually, in the late 2000s, the Blue Nile was estimated to be the "best undeveloped sites for hydropower development globally."[1507] Finally, it is most viable to withdraw

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[1505] World Bank, "World Development Indicators," *The World Bank Databank*, 2017, available at: http://data.worldbank.org (accessed 31 January 2017).

[1506] Dale Whittington, Xun Wu & Claudia Sadoff, "Water Resources Management in the Nile Basin: The Economic Value of Cooperation," *Water Policy*, vol. 7, no. 3, 2005, pp.11-12.

[1507] Marc Jeuland, Xun Wu & Dale Whittington, "Infrastructure Development and the Economics of Cooperation in the Eastern Nile," *Water International*, vol. 42, no. 2, 2017, p.121.

water “where its user value is greatest,” in other words, the water should be used by those who uses it “most productively.”[1508] The authors estimated a gross benefit between 7 and 11 billion US dollars from the water use in the Nile River basin from irrigation and hydroelectricity generation.[1509] The subject of hydroelectricity and power trade will be discussed in some detail in the following section.

7.4. Electricity and interconnections

Water demand throughout the Nile River basin has been increasing for a while driven by economic and population growth.[1510] On the other hand, a major economic setback of the Nile basin is poverty.[1511] Lack of access both to electricity and water is an unfortunate characteristic of the upstream countries, despite significant development in the Sudan, Uganda, and Rwanda between 2012 and 2014, in terms of access to electricity.[1512] In this respect, the upstream Nile River countries are comparable to those in Southeast Asia, especially the Mekong River basin, as scrutinized in this study. South Sudan, Burundi, Democratic Republic of Congo, Tanzania, Rwanda, Uganda, and Ethiopia were among the least electrified

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[1508] Dale Whittington, Xun Wu & Claudia Sadoff, "Water Resources Management in the Nile Basin: The Economic Value of Cooperation," *Water Policy*, vol. 7, no. 3, 2005, p.13.

[1509] This estimation excludes the costs of operation and maintenance costs of the infrastructure. See: Dale Whittington, Xun Wu & Claudia Sadoff, "Water Resources Management in the Nile Basin: The Economic Value of Cooperation," *Water Policy*, vol. 7, no. 3, 2005, p.28.

[1510] Reem Digna, et al., "Nile River Basin Modelling for Water Resources Management – A Literature Review," *International Journal of River Basin Management*, vol. 15, no. 1, 2017, p.32; Dagmawi Degefu & Weijun He, "Water Bankruptcy in the Mighty Nile River Basin," *Sustainable Water Resources Management*, vol. 2, no. 1, 2016, pp.32-33.

[1511] Okbazghi Yohannes & Keren Yohannes, "Turmoil in the Nile River Basin: Back to the Future?," *Journal of Asian and African Studies*, vol. 48, no. 2, 2012, p.196.

[1512] World Bank, *Global Tracking Framework 2017 - Progress Toward Sustainable Energy*, The World Bank, 2017, available at: http://gtf.esmap.org/data/files/download-documents/eegp17-01_gtf_full_report_final_for_web_posting_0402.pdf (accessed 13 April 2017).

countries in the world by 2014.[1513] The lowest electrification in the region is in South Sudan, with about 30 megawatts of generation capacity and 2 percent of electrification level.[1514]

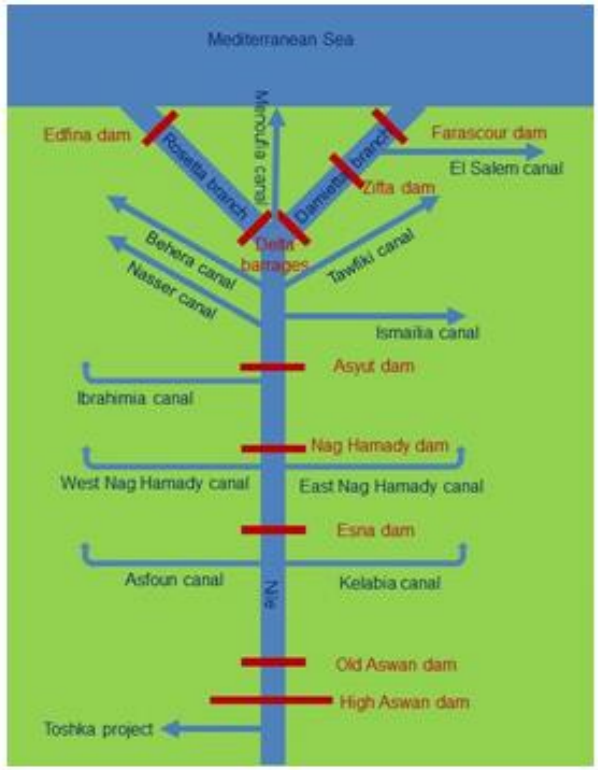

Figure 7.5. Main dams and canals in Egypt in the Nile River basin[1515]

[1513] World Bank, *Global Tracking Framework 2017 - Progress Toward Sustainable Energy*, The World Bank, 2017, available at: http://gtf.esmap.org/data/files/download-documents/eegp17-01_gtf_full_report_final_for_web_posting_0402.pdf (accessed 13 April 2017), p.42.

[1514] World Bank, *The Nile Story: Powering the Nile Basin*, The World Bank, 2015, available at: http://documents.worldbank.org/curated/en/344461468197979073/The-Nile-story-powering-the-Nile-basin (accessed 21 April 2017), p.7.

[1515] Food and Agriculture Organization of the United Nations, "Egypt: Water Resources," *Aquastat*, 2016, available at:

Although the potential is high, the lack of access to electricity and the unreliable electricity transmission network in the Nile basin are major setbacks for economic development.[1516] These will be discussed in this section.

7.4.1. Economy and electricity production

Electrification attempts in Egypt date back to the late nineteenth century. By 1893, some houses in Cairo and Alexandria had access to low voltage and direct current electricity, and electric powered street lamps.[1517] Today, Egypt has by far the greatest installed electricity generation capacity, 31.5 gigawatts as of 2015.[1518] A significant portion of this electricity is produced from thermal sources.[1519] Regarding hydroelectricity, Egypt has already exploited almost all of its potential. The largest capacity HPP in Egypt is at the Aswan High Dam with 12 turbines, operational since 1971. The Aswan Dam has an installed capacity of 2,100 megawatts and a generating capacity of 1 TWh annually.[1520] As of 1974, it generated

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http://www.fao.org/nr/water/aquastat/countries_regions/Profile_segments/EGY-WR_eng.stm (accessed 10 September 2017).

[1516] World Bank, *The Nile Story: Powering the Nile Basin*, The World Bank, 2015, available at: http://documents.worldbank.org/curated/en/344461468197979073/The-Nile-story-powering-the-Nile-basin (accessed 21 April 2017), p.2.

[1517] Nadia Abdelsalam, Medhat Aziz & Asmaa Agrama, "Quantitative and Financial Impacts of Nile River Inflow Reduction on Hydropower and Irrigation in Egypt," *Energy Procedia*, vol. 50, 2004, p.654.

[1518] Amanda Figueras, "Electricity in Egypt: The Whole Picture," *Egypt Oil and Gas*, 2016, available at: http://www.egyptoil-gas.com/publications/electricity-in-egypt-the-whole-picture/ (accessed 2 April 2017).

[1519] Deloitte, *The Roadmap to a Fully Integrated and Operational East African Power Pool*, 2015, available at: https://www2.deloitte.com/content/dam/Deloitte/ke/Documents/energy-resources/ER_Power%20TL.pdf (accessed 30 March 2017), p.12.

[1520] Nile Basin Initiative, *Review of Hydropower Multipurpose Project Coordination Regimes*, NBI, 2008, available at: http://nileis.nilebasin.org/system/files/NBI_%20Best%20Practice%20Compendium_Final.pdf (accessed 12 April 2017), p.46.

more than half of the total electricity in the country. This share has decreased since then with the addition of further HPPs.[1521]

Egypt is the center for energy demand in the Northeast Africa. With about 152 TWh of annual electricity consumption in 2016, Egypt alone consumes almost one quarter of total electricity consumed in African continent. Total electricity produced in the same year was 190 TWh and in the last decade, Egypt has been a net electricity exporter.[1522] Egypt possesses by far the greatest installed electricity generation capacity in the Nile River basin, which reaches to 31.5 gigawatts as of 2015.[1523] Hydroelectricity constitutes a small portion of this capacity[1524] mostly because of ineligible geography for hydropower generation, and almost 85 percent of its total potential was already exploited. This share is lower in the downstream countries. The major challenger and an important part of the Nile River basin, Ethiopia, possesses about 45 gigawatts of hydropower potential, of which only 6 percent was exploited in the beginning of the 2010s.

[1521] Nile Basin Initiative, *Review of Hydropower Multipurpose Project Coordination Regimes*, NBI, 2008, available at: http://nileis.nilebasin.org/system/files/NBI_%20Best%20Practice%20Compendium_Final.pdf (accessed 12 April 2017), p.47. See also: Asit Biswas, "Aswan Dam Revisited: The Benefits of a Much Maligned Dam," *Development and Cooperation*, vol. 6, 2002.

[1522] Enerdata, "Electricity Trade," *Global Energy Statistical Yearbook*, 2016, available at: https://yearbook.enerdata.net/electricity/electricity-balance-trade.html (accessed 12 October 2017).

[1523] Amanda Figueras, "Electricity in Egypt: The Whole Picture," *Egypt Oil and Gas*, 2016, available at: http://www.egyptoil-gas.com/publications/electricity-in-egypt-the-whole-picture/ (accessed 2 April 2017).

[1524] Deloitte, *The Roadmap to a Fully Integrated and Operational East African Power Pool*, 2015, available at: https://www2.deloitte.com/content/dam/Deloitte/ke/Documents/energy-resources/ER_Power%20TL.pdf (accessed 30 March 2017), p.12.

Table 7-4. Major dams and HPPs on the Nile River[1525]

Dam name	Country	Purpose	Installed capacity
Aswan High	Egypt	Flood protection, hydropower, irrigation, storage, fisheries	2,100 megawatts
Roseires	Sudan	Hydropower, irrigation of the Gezira plains, fisheries	1,800 megawatts[1526]
Sennar	Sudan	Irrigation and hydropower	15 megawatts
Khashm El Gibra	Sudan	Irrigation, water supply, and hydropower	13 megawatts
Merowe	Sudan	Hydropower, irrigated agriculture, flood protection, silt trapping	1,250 megawatts
Gilgel Gibe III	Ethiopia	Hydropower, flood protection	1,870 megawatts
Finchaa	Ethiopia	Hydropower and irrigation	100 megawatts
Koka	Ethiopia	Hydropower	107 megawatts
Owen Falls	Uganda	Hydropower	300 megawatts

1525 The capacities of some dams may differ from the original source as they may be upgraded since 2008. Nile Basin Initiative, *Review of Hydropower Multipurpose Project Coordination Regimes*, NBI, 2008, available at: http://nileis.nilebasin.org/system/files/NBI_%20Best%20Practice%20Compendium_Final.pdf (accessed 12 April 2017), pp.136-37.

1526 The initial installed capacity of the Roseires Dam was 280 megawatts when it was completed in 1971. Since 2013, the capacity was increased to 1,800 megawatts. See: Alloy Steel, "Roseires Dam, Sudan, North Africa," *Alloy Steel International*, 2014, available at: http://alloysteel.net/wp-content/uploads/2014/11/RoseiresDam.pdf (accessed 13 February 2018).

On the other hand, hydroelectricity potential of the Nile River basin in general has been quite undeveloped until recently.[1527] The river basin has long been among the least exploited globally, in terms of hydropower generation. Ethiopia has the highest potential for hydroelectricity production, while its downstream neighbor Sudan has both underexploited hydropower potential, along with the largest areas suitable for irrigation within the basin,[1528] as scrutinized in the previous section.

Recognizing its potential, an emerging investor in the hydroelectricity sector in the Nile River basin has become the Sudan. Although after the beginning of the commercial oil drilling in the Sudan since 1995,[1529] its dependence on hydropower has decreased, the Sudanese governments continued investing in hydroelectricity and completed the 1,200-megawatts-capacity Merowe Dam in 2009.[1530] This would contribute to the Sudanese electricity production to a significant degree. However, the oil exporter status of the Sudan has changed since 2011, when the oil-rich South Sudan became independent.[1531] In terms of hydroelectricity, the Sudan used almost 50 percent of its 4,920 megawatts potential. Other countries in the Nile River basin have quite high amounts of unexploited hydropower potential.[1532]

[1527] World Bank, *The Nile Story: Powering the Nile Basin*, The World Bank, 2015, available at: http://documents.worldbank.org/curated/en/344461468197979073/The-Nile-story-powering-the-Nile-basin (accessed 21 April 2017), p.2.

[1528] Ana Cascão, "Changing Power Relations in the Nile River Basin: Unilateralism vs. Cooperation?," *Water Alternatives*, vol. 2, no. 2, 2009, p.253.

[1529] Fadwa Taha, "The History of the Nile Waters in the Sudan," in T. Tvedt, ed. *The River Nile in the Post-Colonial Age: Conflict and Cooperation among the Nile Basin Countries*, 2010, p.197.

[1530] Fadwa Taha, "The History of the Nile Waters in the Sudan," in T. Tvedt, ed. *The River Nile in the Post-Colonial Age: Conflict and Cooperation among the Nile Basin Countries*, 2010, p.196.

[1531] Rawia Tawfik, "Reconsidering counter-hegemonic dam projects: the case of the Grand Ethiopian Renaissance Dam," *Water Policy*, vol. 19, no. 1, 2016, p.6.

[1532] International Renewable Energy Agency, Africa Clean Energy Corridor: Analysis of Infrastructure for Renewable Power in Eastern and Southern Africa, IRENA, 2015, p.35.

Although various sources estimate the potential of hydroelectricity generation quite differently for the upstream countries,[1533] what is clear is that Ethiopia is quite advantageous in that respect and the Ethiopian governments desire to harness this high potential.[1534] In recent years, Ethiopia took steps for liberalizing its economy and began focusing on water development projects that were already proposed by the USBR in the post-colonial era. A major supporter of these projects would be China in about a decade.[1535] After the 6,000 megawatts capacity HPPs of the famous Grand Ethiopian Renaissance Dam[1536] becomes operational, Ethiopia will convert a significant volume of its potential into installed capacity, and will possess almost two-thirds of the total installed hydropower generation capacity in the whole Nile River basin, increasing its current share of 28 percent. This would alter the balances in the basin in terms of renewable electricity composition in favor of Ethiopia. This is one of the most important reasons why, in 2011, Egyptian and Ethiopian authorities met to discuss the possible impacts of this HPP project.[1537] More recently, in 2015, Egypt, the Sudan and Ethiopia agreed on the dam project, in principle.

[1533] Compare, for instance these two sources: Marc Jeuland, Xun Wu & Dale Whittington, "Infrastructure Development and the Economics of Cooperation in the Eastern Nile," *Water International*, vol. 42, no. 2, 2017, p.123 and the report of the International Renewable Energy Agency, *Africa Clean Energy Corridor: Analysis of Infrastructure for Renewable Power in Eastern and Southern Africa*, IRENA, 2015, p.35.

[1534] The Italian Salini Impregilo Spa undertook the 55 percent of the dam building. See: Christabel Ligami, "Egypt Pulls Out of Regional Power Pool as it Protests Use of Nile Waters," *The East African*, 2016, available at: http://www.theeastafrican.co.ke/news/Egypt-pulls-out-of-power-pool-as-it-protests-use-of-Nile-waters/2558-3065704-x4qbu2z/index.html (accessed 2 April 2017).

[1535] Ana Cascão, "Changing Power Relations in the Nile River Basin: Unilateralism vs. Cooperation?," *Water Alternatives*, vol. 2, no. 2, 2009, p.254.

[1536] Salini Impreglio, "Grand Ethiopian Renaissance Dam Project," 2014, available at: https://www.salini-impregilo.com/en/projects/in-progress/dams-hydroelectric-plants-hydraulic-works/grand-ethiopian-renaissance-dam-project.html (accessed 9 September 2017).

[1537] Aljazeera, "South Sudan set to sign new Nile agreement," *Aljazeera*, 2013, available at: http://www.aljazeera.com/news/africa/2013/06/201362075235645727.html (accessed 13 March 2017).

Depending on the internal demand, the excess electricity will be exported to the neighboring countries, primarily to the Sudan.[1538] Also, the excess electricity is planned to be exported to the East Africa power grid, a project of electricity transmission lines covering part of the Nile River basin.[1539] The Grand Ethiopian Renaissance Dam is set to finish in 2017. Some find the importance of the dam overrated and some[1540] claim that the officially-announced 6,000 megawatt capacity of the dam is an overestimation arguing that the Blue Nile River flow could not support such a capacity.[1541]

There are some further developments in the Nile River basin as well (Table 7-4). In 2016, the 1.87 gigawatts Gibe III HPP was completed, almost doubling the installed capacity of the country. Some 50 percent of the total electricity generation of the latter HPP will be exported to neighbors, Kenya, the Sudan, and Djibouti. New transmission lines are planned to be constructed for this electricity trade.[1542] In parallel, the Ethiopian government desires to improve the transmission capacity. Ethiopia aims to construct new 500 kV transmission lines from the Grand Renaissance Dam to Sudan (GERD-Rabak interconnector), along with the already existing 230

[1538] Ethiopian Electric Power Corporation, *Power Sector Development*, National Association of Regulatory Utility Commissioners, 2014.

[1539] Fred Pearce, "On the River Nile, a Move to Avert a Conflict Over Water," *Yale Environment 360*, 2015, available at: http://e360.yale.edu/features/on_the_river_nile_a_move_to_avert_a_conflict_over_water (accessed 13 March 2017).

[1540] Rawia Tawfik, "Reconsidering counter-hegemonic dam projects: the case of the Grand Ethiopian Renaissance Dam," *Water Policy*, vol. 19, no. 1, 2016, p.5.

[1541] Wangechi Kiongo, "5 Myths Surround the Grand Ethiopian Renaissance Dam (GERD)," *International Rivers*, 2017, available at: https://www.internationalrivers.org/blogs/732/5-myths-surround-the-grand-ethiopian-renaissance-dam-gerd (accessed 12 March 2017); Jean Kumagai, "The Grand Ethiopian Renaissance Dam Gets Set to Open," *IEEE Spectrum*, 2016, available at: http://spectrum.ieee.org/energy/policy/the-grand-ethiopian-renaissance-dam-gets-set-to-open (accessed 12 March 2017).

[1542] REN21, *Renewables 2017 Global Status Report*, Renewable Energy Policy Network for the 21st Century, 2017, p.57.

kV transmission lines between the countries.[1543] These will be subject to debate in the following paragraphs.

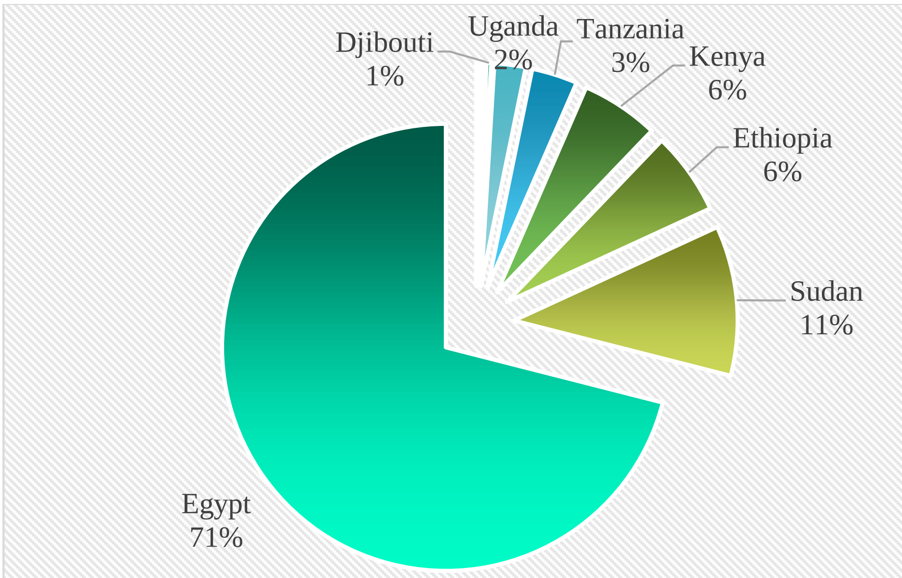

Figure 7.6. Installed electricity capacity share in Eastern Africa in 2012[1544]

7.4.2. Interconnections

Egypt is connected to Libya in the west and Jordan in the east. The country has a double circuit 500 kV connection between Aswan High Dam and Cairo. From Cairo, a single circuit connects it to Jordan with 500/400 kV lines. Also, 220 and 132 kV

[1543] Ethiopian Electric Power Corporation, *Power Sector Development*, National Association of Regulatory Utility Commissioners, 2014.

[1544] Deloitte, *The Roadmap to a Fully Integrated and Operational East African Power Pool*, 2015, available at: https://www2.deloitte.com/content/dam/Deloitte/ke/Documents/energy-resources/ER_Power%20TL.pdf (accessed 30 March 2017), p.12.

lines feed the Nile Delta from Cairo. The delta network extends towards Libya with 220 kV transmission lines.[1545]

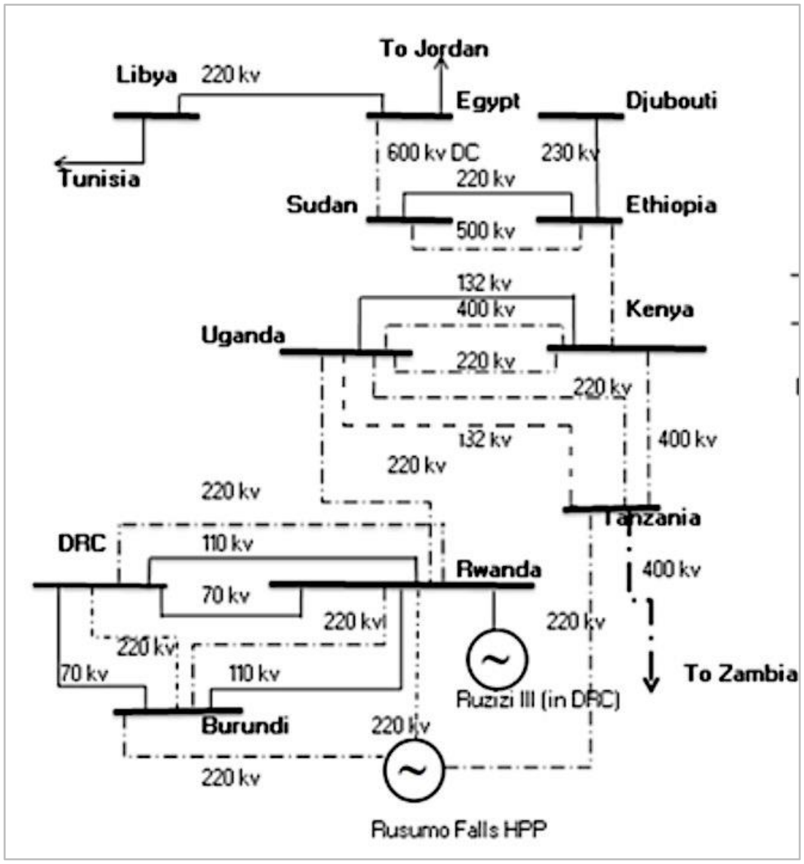

Figure 7.7. Existing and planned (dashes) interconnections in the EAPP zone[1546]

[1545] Fatma Moustafa, "Electrical Interconnection Project Between Egypt, Sudan and Ethiopia," in *The Role of Electricity Networks in Supporting Sustainability and Regional Integration*., 2009, p.2.

[1546] Joseph Magochi, *Development of Regional Power Trade in East Africa*, East Africa Regional Regulatory Partnership, 2014.

The interconnection in the Eastern Africa is titled the Eastern Africa Power Pool (EAPP), which is established under the Common Market for Eastern and Southern Africa, as an agency of energy.[1547] This structure was set up after the signing of the memorandum of understanding between Burundi, Democratic Republic of Congo, Egypt, Ethiopia, Kenya, Rwanda and the Sudan in 2005. The Secretary-General of this international organization resides in Ethiopia, at Addis Ababa. Tanzania, Libya, and Uganda joined the EAPP agreement between 2010 and end-2012, respectively. The aim of the EAPP is reducing costs of transmission and distribution and increasing efficiency by pooling resources.[1548] The EAPP was financially supported by the European Commission, the Ministry of Foreign Affairs of Norway, and the US (USAID).[1549]

The first regional master plan of the EAPP was finalized in May 2011.[1550] Under the framework of the EAPP, in 2012, some interconnection projects were planned. Among them was the 600 kV DC interconnection between Egypt and the Sudan with 2,000 megawatts of capacity, and planned to be finished by 2016 (Figure 7.7).[1551] Numerous other projects were also planned, e.g. between Ethiopia and

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[1547] Deloitte, *The Roadmap to a Fully Integrated and Operational East African Power Pool*, 2015, available at: https://www2.deloitte.com/content/dam/Deloitte/ke/Documents/energy-resources/ER_Power%20TL.pdf (accessed 30 March 2017), p.8.

[1548] Eastern Africa Power Pool *The Eastern Africa Power Pool Website*, 2016, available at: http://eappool.org/ (accessed 13 March 2017).

[1549] Jasper Oduor, "Eastern Africa Power Pool," in *Intergovernmental Authority on Development Investment Conference, 12-13 March 2012.*, 2012, pp.16-22.

[1550] Ephrem Tesfaye, *Eastern Africa Power Pool Profile*, East Africa Regional Partnership Exchange Program, 2014.

[1551] Jasper Oduor, "Eastern Africa Power Pool," in *Intergovernmental Authority on Development Investment Conference, 12-13 March 2012.*, 2012, p.11; Deloitte, *The Roadmap to a Fully Integrated and Operational East African Power Pool*, 2015, available at: https://www2.deloitte.com/content/dam/Deloitte/ke/Documents/energy-resources/ER_Power%20TL.pdf (accessed 30 March 2017), p.13; International Renewable Energy Agency, *Africa Clean Energy Corridor: Analysis of Infrastructure for Renewable Power in Eastern and Southern Africa*, IRENA, 2015, p.xi.

Kenya, Tanzania and Kenya, Ethiopia and Sudan, and the Rusumo Falls HPP project[1552] transmission lines.[1553] In 2014, the first master plan was updated.[1554]

Under the EAPP framework, according to a Chief Engineer from the Egyptian Electricity Holding Company, Uganda, Ethiopia, Rwanda and Democratic Republic of Congo have electricity export potential. Egypt, on the other hand, is expected to generate 60 percent of the total electricity under the EAPP project, and will neither be a net exporter nor a net importer. Importing countries are Djibouti, Kenya, Burundi, the Sudan, and Tanzania.[1555] Yet, a Deloitte report shows that by 2030, Egypt would most probably be a net exporter with a total of 2,540 megawatts of surplus electricity. For this to be achieved, the 2012 installed capacity of 25,879 megawatts would almost be tripled to 72,449 megawatts by 2030. On the other hand, most of the surplus would emerge from Ethiopia and Sudan, respectively.[1556] In the EAPP, more than half of the total electricity demand will be met by hydroelectricity, in the short-term.[1557] Projections indicate an annual increase in electricity demand at 7 to 9 percent between 2000 and 2025 in the whole EAPP zone.[1558]

[1552] Nile Basin Initiative, "Regional Rusumo Falls Hydroelectric Project," *Rusumo Project*, 2012, available at: http://rusumoproject.org/index.php/en/ (accessed 1 April 2017).

[1553] Jasper Oduor, "Eastern Africa Power Pool," in *Intergovernmental Authority on Development Investment Conference, 12-13 March 2012*., 2012, pp.11-12.

[1554] Ephrem Tesfaye, *Eastern Africa Power Pool Profile*, East Africa Regional Partnership Exchange Program, 2014.

[1555] Safaa Hamed, "Eastern Africa Power Pool," in *Energy Efficiency Workshop, March 2010*., 2010, p.11.

[1556] Deloitte, *The Roadmap to a Fully Integrated and Operational East African Power Pool*, 2015, available at: https://www2.deloitte.com/content/dam/Deloitte/ke/Documents/energy-resources/ER_Power%20TL.pdf (accessed 30 March 2017), p.12

[1557] International Renewable Energy Agency, Africa Clean Energy Corridor: Analysis of Infrastructure for Renewable Power in Eastern and Southern Africa, IRENA, 2015, p.49.

[1558] Ephrem Tesfaye, *Eastern Africa Power Pool Profile*, East Africa Regional Partnership Exchange Program, 2014.

While the EAPP is proposed for regional cooperation in energy area and thus got international recognition and support, Egypt seems to dominate the interconnection network in the basin. In early 2016, the ministers of ten East African countries, Burundi, Democratic Republic of Congo, Egypt, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, Libya, and Uganda, met in Addis Ababa. At this meeting, Egypt announced that it has withdrawn from the EAPP because of a dispute over the Nile water usage as the Sudan and Ethiopia have plans of HPPs on the Nile. Although Egypt objects these plans, the master plan for the EAPP was already approved, and the project is underway without the Egypt-Sudan interconnection.[1559]

One of the main components of the Shared Vision Program of the NBI is Regional Power Trade Project. This project is foreseen to develop common power markets. The program included training of government officials and technical personnel. The studies under the umbrella of the NBI showed that hydropower production might generate 65 percent of the total electricity demand in the region.[1560]

The efforts of the NBI facilitated the establishment of the EAPP. In the Nile Equatorial Lakes region, the World Bank and the NBI worked with the EAPP and invested 530 million US dollars as of 2015. The project would, in total, transfer 995 megawatts of electricity. In the Equatorial Nile region.[1561] Another project initiated in 2013 connects Ethiopia and Sudan with 296 kilometers of transmission lines, carrying 1,200 megawatts of electricity. This project provided electricity to about 8

[1559] Christabel Ligami, "Egypt Pulls Out of Regional Power Pool as it Protests Use of Nile Waters," *The East African*, 2016, available at: http://www.theeastafrican.co.ke/news/Egypt-pulls-out-of-power-pool-as-it-protests-use-of-Nile-waters/2558-3065704-x4qbu2z/index.html (accessed 2 April 2017).

[1560] World Bank, *The Nile Story: Powering the Nile Basin*, The World Bank, 2015, available at: http://documents.worldbank.org/curated/en/344461468197979073/The-Nile-story-powering-the-Nile-basin (accessed 21 April 2017), p.2.

[1561] World Bank, *The Nile Story: Powering the Nile Basin*, The World Bank, 2015, available at: http://documents.worldbank.org/curated/en/344461468197979073/The-Nile-story-powering-the-Nile-basin (accessed 21 April 2017), p.5.

million people, and Ethiopia has gained about 9 million US dollars from the electricity exports annually. The Sudanese electricity users also benefited from the lower imported electricity prices.[1562]

7.5. Conclusion

Egypt is the most arid and most water dependent case analyzed in this study. High irrigation water demand and limited supply made it subject to numerous studies on hydropolitics. It is an appropriate case for a dominant downstream country in a riparian relationship. In that respect, the hydropolitical relations of Egypt is comparable to those of Uzbekistan as analyzed in the previous chapter.

The Aswan High Dam is world famous, and one of the most studied symbols of politicization of hydraulic works. The political history made Egypt the most prominent country within the basin, a situation testified by the international treaties. These treaties are among the best indicators of the asymmetrical status of the water resources policies followed by colonial powers. Especially in Africa, the colonial powers did their best to protect their interests against the other states. The treaties signed at that time, along with the water practices and policies, are the main source of current water problems in the basin. In terms of agricultural policies applied by the colonial powers, and particularly in terms of cotton cultivation, Egypt is, again, comparable to Uzbekistan.

Hydroelectricity and power trade in Egypt, on the other hand, became subject to a lesser number of studies, not without a reason. Egypt is not among the world's top hydropower spots, and the country has already exploited most of its hydropower generating potential. In terms of power trade, Egypt is currently not connected to the upstream riparians and its governments have thus far strongly opposed the construction of large dams with HPPs in the upstream of the basin, let alone buying electricity from them. Despite this resistance of Egypt, there have been significant

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[1562] World Bank, *The Nile Story: Powering the Nile Basin*, The World Bank, 2015, available at: http://documents.worldbank.org/curated/en/344461468197979073/The-Nile-story-powering-the-Nile-basin (accessed 21 April 2017), p.6.

hydropower projects in the upstream countries and the current decade witnessed many of them come true one after another.

The next step here is to connect Egypt to the upstream riparians through the newly constructed ultra high voltage transmission lines, with the support and encouragement of the international organizations and donors. Egypt is one of the key actors in the East and North African interconnections, and one may predict that it would benefit from the realization of transboundary power trade schemes in the region.

CHAPTER VIII

CONCLUSION

> As much as irrigation development was a colonial project pursued with vigour, it was a process of trial and error that happened at great social cost.
>
> Molle et al., 2009[1563]

The discussion in the literature on water is not unrelated to high-politics, and a considerable number of authors in the academic and popular literature pay attention to the links between power politics, water scarcity, and interstate conflicts. In contrast to this somehow pessimistic[1564] Malthusian approach to the relationship between population growth and the scarcity of natural resources, a group of analysts look to the water issues through the lenses of a more optimistic and liberal worldview. They underline possible scenarios in which water leads interstate and regional cooperation and integration through the encouragement and aid from the international organizations and through the implementation of the principles of international regimes and regulations. Both the presence and operation of the international and local organizations are closely related to international politics,[1565] and this can be

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[1563] F. Molle, P.P. Mollinga & P. Wester, "Hydraulic Bureaucracies and the Hydraulic Mission: Flows of Water, Flows of Power," *Water Alternatives*, vol. 2, no. 3, 2009, p.329.

[1564] Thomas Homer-Dixon, "On the Threshold: Environmental Changes as Causes of Acute Conflict," *International Security*, vol. 16, no. 2, 1991.

[1565] Charles Howe & John Dixon, "Inefficiencies in Water Project Design and Operation in the Third World: An Economic Perspective," *Water Resources Research*, vol. 29, no. 7, 1993; J.

observed in the process of historical development of various international organizations, donors, as well as in the financing processes of large hydraulic projects elsewhere in the developing world. The discourse embraced in this literature is typically and strictly linked to the RBM, IWRM, and water governance concepts.

Water-related conflict or institutionalized cooperation in transboundary water issues are valuable inputs for the analysis in this study as they are major indicators of the nature of hydropolitical relations between riparians in a river basin. On the other hand, this is only one aspect of the analysis, and as the "three spheres of water discourse" as conceptualized by Selby[1566] are closely related with the political discourse, the technical issues of hydroelectricity generation and trade are scrutinized here with regards to transboundary politics. In a similar vein, the technical framework, also known as the nexus, is closely tied to politics and economy, and has become a viable basis for scrutinizing water and water-related energy, agriculture, and environment issues. As these elements establish a complex, the analysis should more appropriately be based on these issue linkages. The analysis in this study builds upon a nexus of electricity trade and hydropolitics, and it aims to focus mainly on the political and economic aspects of it.

Water-related issues are often politicized,[1567] and the level of politicization is higher in water-related energy topics, especially in hydroelectricity generation and irrigation issues in transboundary river basins. As water management practices and policies are regarded by the governments around the world as the primary areas of interest for supporting economic development and growth, states have reclaimed wide areas in key transboundary river basins and constructed large dams on major

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Allan, "IWRM: The New Sanctioned Discourse," in P.P. Mollinga, A. Dixit & K. Athukorala, eds. *Integrated Water Resources Management: Global Theory, Emerging Practice and Local Needs*, 2006; François Molle, Peter Mollinga & Philippus Wester, "Hydraulic Bureaucracies and the Hydraulic Mission: Flows of Water, Flows of Power," *Water Alternatives*, vol. 2, no. 3, 2009.

[1566] Selby has divided the discourse on water into three spheres, i.e., ecological, technical, and political discourses. See: Jan Selby, *Water, Power and Politics in the Middle East The Other Israeli–Palestinian Conflict* (London & New York: I.B. Tauris, 2003).

[1567] Jeroen Warner & Kai Wegerich, "Is Water Politics? Towards International Water Relations," in K. Wegerich & J. Warner, eds. *The Politics of Water: A Survey* 1st ed., 2010, p.3.

rivers. To do this, they established comprehensive bureaucratic mechanisms and have been directly involved in water management and hydropower schemes. For addressing the problems of increasing water demand driven by economic and population growth, along with agricultural and environmental water use, the governments have long endeavored to increase water supply, but more recently, they have focused on managing water demand instead of generating new supply. While most of the freshwater in the world is demanded and withdrawn by agricultural sector, other sectors, such as the hydropower industry, often exclusively demand significant amounts of freshwater, mostly in the storages behind great dams. Examples of this dilemma is observed in key transboundary river basins around the world, some of the most important among which are investigated this study.

The circumstance that the political boundaries of the states often do not overlap geographical boundaries of the catchment areas of major transboundary rivers[1568] establishes a major and complex issue area for IR inquiry. Table 8-1 gives some key indicators for the selected river basins scrutinized in this study. The basin surface areas, along with the indicators of population and water runoff show considerable variance among the river basins. Also, the climate of the selected cases differ significantly from each other. The Colorado, the Rio Grande, the Aral Sea, and the downstream Nile River basins are in the arid and semi-arid climate zones of the globe. Other river basins receive relatively higher precipitation. In parallel, in some basins, because of low annual water availability,[1569] a physical scarcity of water may be observed. Aridity and water scarcity coupled with hydropower-agriculture

[1568] See, for a discussion on geography in social inquiry: Brian Page, "Agriculture," in E. Sheppard & T.J. Barnes, eds. *A Companion to Economic Geography*, 2003, p.253.

[1569] R. Sternberg, "Hydropower's future, the environment, and global electricity systems," *Renewable & Sustainable Energy Reviews*, vol. 14, no. 2, 2010, p.715.

differences and exacerbated by climate change are important catalyzers of hydro-political dispute among riparians, and bilateral political problems tend to be decisive in that respect.

Table 8-1. Main indicators for selected river basins[1570]

Basin Name	Area (thousand km^2)	Population (thousand)	Runoff (mm/year)	Discharge (km^3/year)
Aral Sea	1,219	50,052	103	126.09
Colorado	626	8,794	40	25.19
Columbia	653	7489	358	233.76
Mekong	773	58,743	647	500.39
Nile	2,933	174,365	129	379.34
Rio Grande	538	10,969	23	12.11
Salween	265	7,851	662	175.70

Some countries assessed in this study have more than 50 percent of their total surface areas within a single river basin, such as Tajikistan, Uganda, Laos, Cambodia, Uzbekistan, Rwanda, the Sudan (now parted into two), and Kyrgyzstan. For these countries, in general, a basin-wide deterioration in the water resources or large-scale water development projects are expected to have greater impacts on the economic conditions. But a sounder guide here may be the level of economic dependence on water resources. In parallel to their share in river basins, some of these countries have a relatively higher economic dependence on water resources, however, exceptions to this general trend may occur (Figure 8.2). Most notable exceptions are the cases of Kyrgyzstan, Egypt, Mexico, Canada, or India. Egypt, for instance, has 21 percent in the Nile River basin, but most of its territory is covered

[1570] UNEP/GEF, "Transboundary Waters Assessment Programme - River Basins," *TWAP*, 2016, available at: http://twap-rivers.org/indicators/ (accessed 5 October 2017).

by deserts and the most fertile regions remain within the catchment zone of the river,[1571] and therefore has a high dependence on the Nile waters. Similarly, Mexico, Canada, and India have only limited shares in the river basins, and the economic dependence on water is relatively high because of high demand for irrigation, industrial, and domestic water demand. In contrast, Kyrgyzstan has 60 percent of land in the Aral Sea basin, but as the agricultural zones and the hydropower installed capacity of the country are very limited, its economic dependence is relatively low, but its downstream neighbor, Uzbekistan, has a very high dependence on water resources of the basin (Figure 8.2). This has an impact on hydropolitical relations between these two countries. On the river basin level, dependence on water resources is remarkably high in some basins,[1572] as observed in the Nile, the Ganges-Brahmaputra-Meghna, the Indus, the Nelson-Saskatchewan, the Mekong, the Irrawaddy, and the Aral Sea basins, while it is lower elsewhere, for example in the basins of West America (Figure 8.3).

[1571] World Energy Council, "Energy Resources - Hydropower," *worldenergy.org*, 2016, available at: https://www.worldenergy.org/data/resources/resource/hydropower/ (accessed 5 October 2017).

[1572] According to the calculations of the UNEP/GEF, "Transboundary Waters Assessment Programme - River Basins," *TWAP*, 2016, available at: http://twap-rivers.org/indicators/ (accessed 5 October 2017).

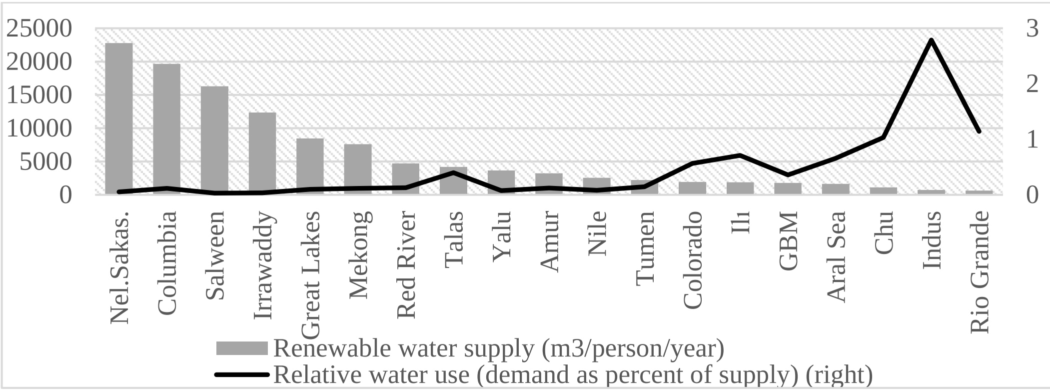

Figure 8.1. Renewable water supply and relative water use for selected basins[1573]

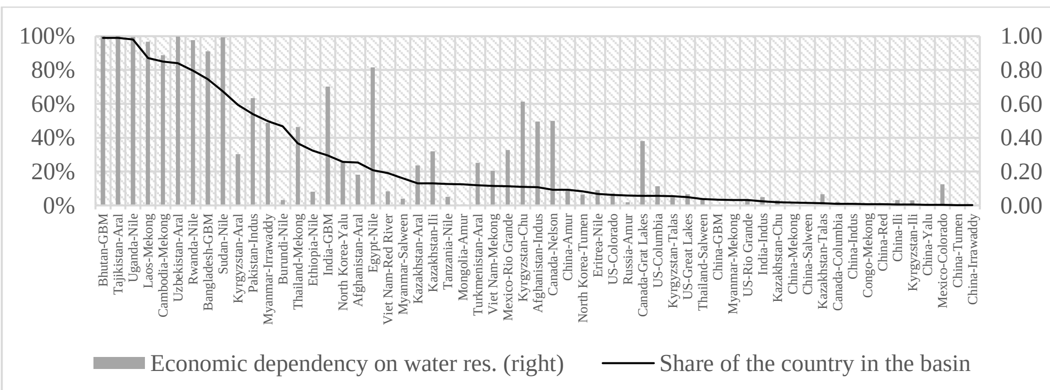

Figure 8.2. Areas within the river basins and economic dependence on water[1574]

[1573] UNEP/GEF, "Transboundary Waters Assessment Programme - River Basins," *TWAP*, 2016, available at: http://twap-rivers.org/indicators/ (accessed 5 October 2017). Renewable water supply is "computed as the internal water supplies available to the basin divided by the total population in the transboundary basin." Water supply is computed as the "sum of volume of discharge generated locally in the basin (long-term annual average discharge over years 1971-2000" in cubic meters. Relative water use is "computed as the mean annual withdrawals (by sectoral and total water use) divided by internal and upstream water supplies available to the basin." Total withdrawals are in cubic kilometers per year. Water supply is the "sum of volume of discharge generated locally in the basin (long-term annual average discharge over years 1971-2000)."

[1574] UNEP/GEF, "Transboundary Waters Assessment Programme - River Basins," *TWAP*, 2016, available at: http://twap-rivers.org/indicators/ (accessed 5 October 2017); Index Mundi, "Surface

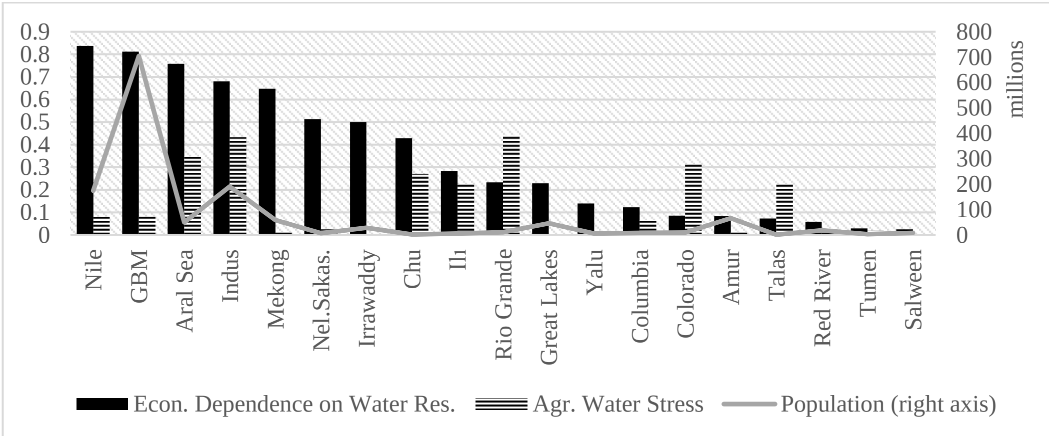

Figure 8.3. Population and economic dependence on water in selected basins[1575]

The dependence on water resources on transboundary level has been a substantial catalyzer to the increase of the number and scope of the international organizations involved in water management and development. Major international organizations occasionally supported environmentally controversial projects for the sake of promoting regional development, primarily through hydropower. This process is in parallel to the escalated modernization and bureaucratization of the water business in the second half of the twentieth century beginning with a trend initiated by state involvement in water sector in developed countries.

Almost everything began with large scale irrigated agricultural activity, which has been among the major elements that increased the involvement of public sector. The nearly parallel development of agriculture in some industrialized countries,

area (sq. km) - Country Ranking," *Index Mundi*, 2015, available at: https://www.indexmundi.com/facts/indicators/AG.SRF.TOTL.K2/rankings (accessed 7 October 2017).

[1575] UNEP/GEF, "Transboundary Waters Assessment Programme - River Basins," *TWAP*, 2016, available at: http://twap-rivers.org/indicators/ (accessed 5 October 2017).

such as in the Fergana Valley, and in the Imperial Valley,[1576] were not completely coincidental[1577] examples of the development of a somehow globalized hydraulic mission.[1578] Such increased involvement of public sector in water development projects augmented the social and environmental impacts on one hand, and on the other, they influenced transboundary hydropolitical relations. Some examples were examined in this study, such as the project that led to the accidental creation of the Salton Sea and the All-American Canal,[1579] or the longest man-made river, the Kara

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[1576] Finis Farr, "History of Imperial County," in *The History of Imperial County*, 1918, p.9; Elwood Mead, W. Schlecht, C. Grunsky & Porter Preston, *The All-American Canal: Report of the All-American Canal Board*, Department of the Interior, 1920, p.9. See also: C. Rockwood, "Early History of Imperial County," in *The History of Imperial County*, 1918, p.98; California Department of Fish and Wildlife, A History of the Imperial Valley, 2000.

[1577] See, for example: Dana Dalrymple, "American Technology and Soviet Agricultural Development, 1924-1933," *Agricultural History*, vol. 40, no. 3, 1966, p.188. Between 1924 and 1933 the Soviet government imported huge amounts of agricultural machinery and equipment from the US through the Amtorg Trading Corporation established in New York, the managers of which were Soviet officials. See: Lewis Feuer, "American Travelers to the Soviet Union 1917-32: The Formation of a Component of New Deal Ideology," *American Quarterly*, vol. 14, no. 2, 1962, p.142.

[1578] François Molle, Peter Mollinga & Philippus Wester, "Hydraulic Bureaucracies and the Hydraulic Mission: Flows of Water, Flows of Power," *Water Alternatives*, vol. 2, no. 3, 2009. For a more general discussion, see: John Hobson, *The Eastern Origins of Western Civilisation* (Cambridge: Cambridge University Press, 2004).

[1579] Kevin Wehr, *America's Fight over Water: The Environmental and Political Effects of Large-Scale Water Systems* (New York and London: Routledge, 2004), p.57. See: C. Rockwood, "Early History of Imperial County," in *The History of Imperial County*, 1918, pp.136-48 on the story of Salton Sea and the floods. To drain the water in the Salton Sink, small canals were dug, which were then converted into irrigation canals. Currently, these canals are called the New River and the Alamo River. See: Kevin Wehr, *America's Fight over Water: The Environmental and Political Effects of Large-Scale Water Systems* (New York and London: Routledge, 2004), p.58.

Kum project,[1580] or the unfinished Jonglei canal project.[1581] The dominance of modern techniques and ideas of water economy and management since the nineteenth century further increased during the twentieth century, especially during the Cold War era.

In some cases, there is a clear conflict between irrigated agriculture and hydroelectricity generation, as observed in the cases of the Aral Sea basin and the Nile River basin. In other cases, such as in the Mekong, or the Columbia River basins, irrigation and hydroelectricity generation needs of the riparians are in conflict with other issue areas, including inundation, pollution, or ecosystems degradation.

[1580] See, for a history of this project: George Cressey, "Changing the Map of the Soviet Union," *Economic Geography*, vol. 29, no. 3, 1953, p.202. Some suggest that there is a parallel between the ancient course of Amu Darya, the Uzboy, and the Kara Kum project. In the Soviet era, the construction of a canal through Turkmenistan to connect Amu Darya with the Caspian was proposed officially in the Fifth Five-Year Plan in 1951. See: Neil Field, "The Amu Darya: A Study in Resource Geography," *Geographical Review*, vol. 44, no. 4, 1954, pp.535-36. In contrast, Pravilova argues that "… the Kelif Uzbo[y] has no relation to the Amu Darya. It is an old riverbed of Afghan rivers, which was occasionally filled with their runoff in times of excess water." See: Ekaterina Pravilova, "River of Empire: Geopolitics, Irrigation, and the Amu Darya in the Late XIXth Century," *Cahiers d'Asie Centrale*, vol. 17-18, 2009, p.266. For a detailed list of Russian and some Western studies of the Uzboy and a discussion on its history, see: Raphael Pumpelly, *Explorations in Turkestan with an Account of the Basin of Eastern Persia and Sistan* (Washington, D.C: Carnegie Institution of Washington, 1905), pp.37-40. See also: Maya Peterson, *Technologies of Rule: Empire, Water, and the Modernization of Central Asia, 1867-1941*, Harvard University, 2011, pp.75-76; A. Grigoryev, "Soviet Plans for Irrigation and Power: A Geographical Assessment," *The Geographical Journal*, vol. 118, no. 2, 1952

[1581] Laura Parkes, "The Politics of 'Water Scarcity' in the Nile Basin: the Case of Egypt," *Journal of Politics & International Studies*, vol. 9, 2013, p.441; Patrick Keys, "Egypt's Jonglei Canal Gambit," *Water Security*, 2011, available at: https://watersecurity.wordpress.com/2011/03/30/egypts-jonglei-canal-gambit/ (accessed 12 March 2017).

Table 8-2. Water withdrawals in selected basins[1582]

Basin Name	Area [thousand km^3]	Population [thousand]	Discharge [km^3/year]	Freshwater withdrawals [km^3/year]
Aral Sea	1,219	50,052	126.09	106.646
Colorado	626	8,794	25.19	21.945
Columbia	653	7489	233.76	36.080
Mekong	773	58,743	500.39	29.560
Nile	2,933	174,365	379.34	78.400
Rio Grande	538	10,969	12.11	18.860
Salween	265	7,851	175.70	2.586

In developing countries, as scrutinized in this study, most of the water is demanded by agricultural sector.[1583] As an example, in Kyrgyzstan and Uzbekistan, agricultural water use has long been above 90 percent of total freshwater withdrawals (Table 8-2 and Figure 8.4). Similarly, the greatest water user in Egypt and China is agriculture. Total water use in China is considerably high and has increased since 1997. Although less than in China, Egyptian water use is also increasing for a few decades (Figure 8.4). In the US and Canada, industrial use of water is higher. In absolute terms, agricultural production and irrigated high-yield agriculture is dense in the US. Besides, industrial production is on higher levels. Therefore, the absolute total demand of water is relatively large. On the other hand, in contrast to China and Egypt, there is a significant decrease in total freshwater withdrawal both in the US and Canada (Figure 8.4).

[1582] UNEP/GEF, "Transboundary Waters Assessment Programme - River Basins," *TWAP*, 2016, available at: http://twap-rivers.org/indicators/ (accessed 5 October 2017).

[1583] Global agricultural water demand constitutes 70 percent of total water demand. See: United Nations, *The United Nations World Water Development Report*, UN Water, 2017, p.2.

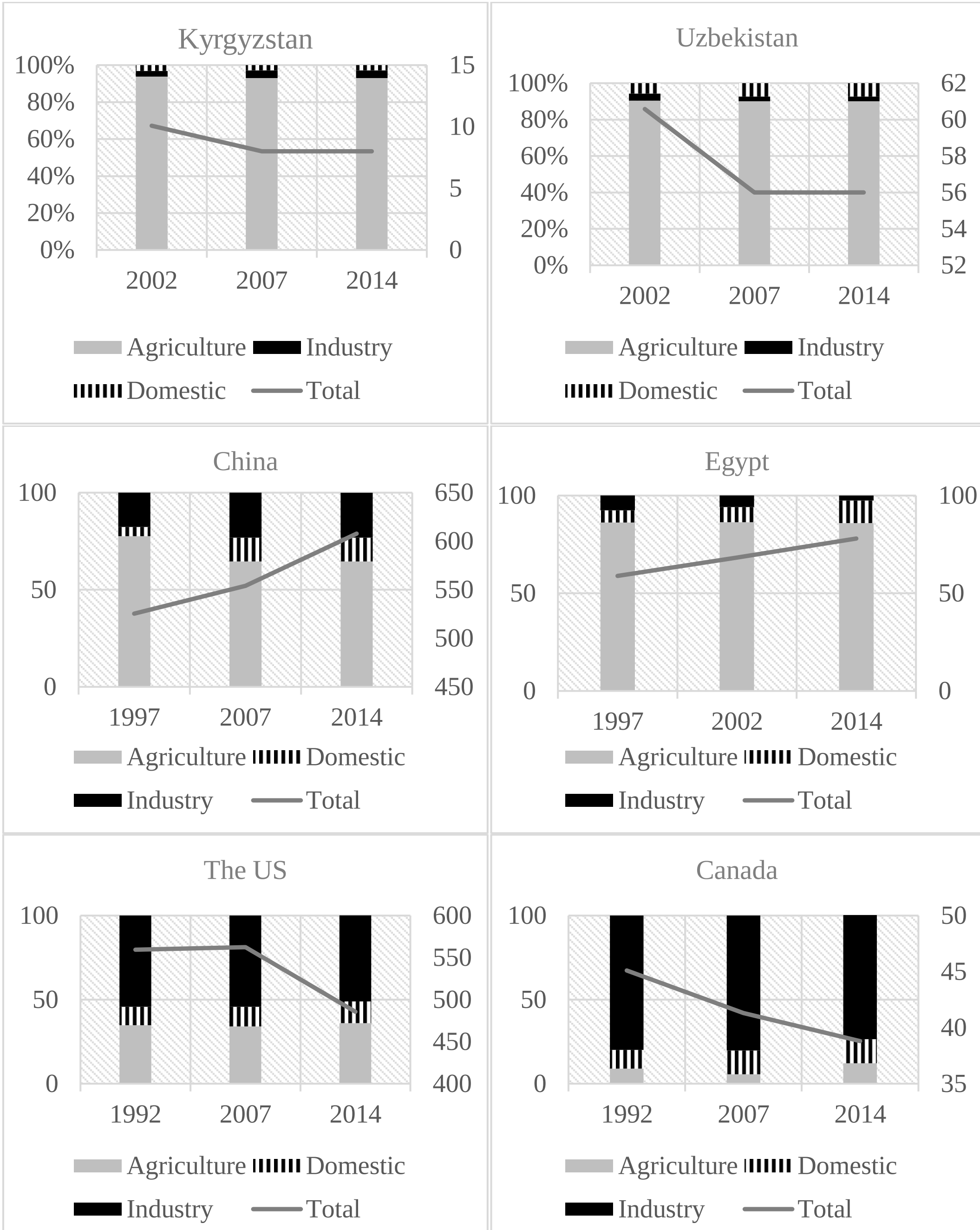

Figure 8.4. Annual freshwater withdrawals of selected countries[1584]

[1584] Data in percent of total (left axes of each graph) and in cubic kilometers (right axes of each graph). World Bank, "World Development Indicators," *The World Bank Databank*, 2017, available at: http://data.worldbank.org (accessed 31 January 2017).

Some countries in the world are estimated to have withdrawn most of their available freshwater resources. Among these are Uzbekistan and Turkmenistan in the Aral Sea basin, and Egypt and the Sudan in the Nile basin, as scrutinized in this study. Figure 8.5 is indicative here. In general, some countries in North Africa, the Middle East and Central Asia are distinguishable as they withdrew almost more than 75 percent of their renewable internal freshwater resources, meaning that they are fully or mostly dependent on the freshwater flows originating from their neighbors, or on virtual trade of water through agricultural products trade.

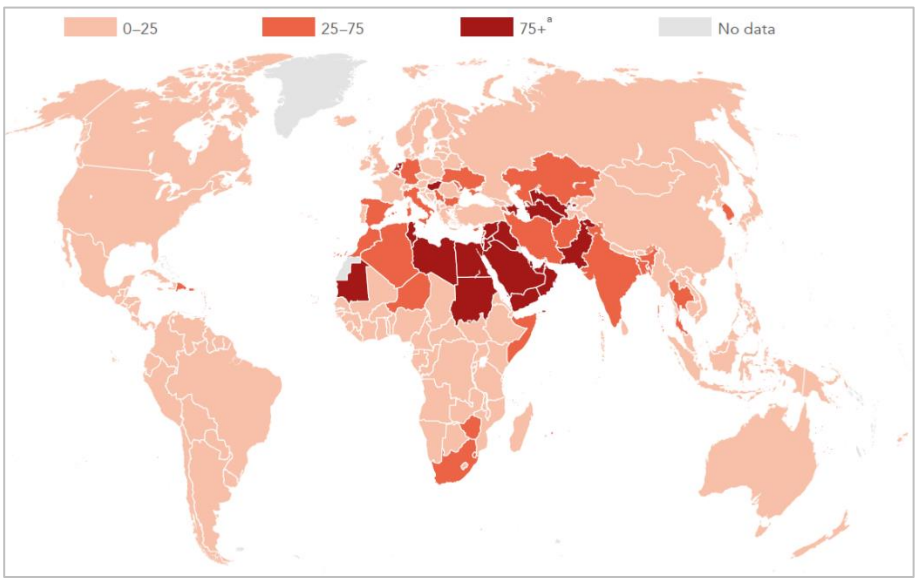

Figure 8.5. Share of total freshwater withdrawals by 2014[1585]

In general terms, agricultural products trade in Africa records deficits in terms of monetary value. In Egypt, in particular, the gap between the import and export value has been widening since the early 2000s and it became even wider after the 2008-

[1585] As percent of internal renewable freshwater resources. World Bank, *Atlas of Sustainable Development Goals 2017: World Development: World Development Indicators*, The World Bank, 2017, p.37.

2010 global economic crisis (Figure 8.6). Uzbekistan recorded agricultural products trade surplus until 2008, but then, the terms of trade balanced and the volume has since increased. Although it performed better than other Central Asian countries in general, as of 2013, the country recorded a small deficit (Figure 8.6). Both Egypt and Uzbekistan are traditional cotton producers, and significant users of blue water. Thus, under such circumstances and under increasing demand for freshwater for renewable energy production, for both countries, increasing the volume of virtual water trade seems to be a viable policy choice.

As an important aspect of the national economic and energy policies, hydroelectricity generation is a common and contested issue area that has impacts not only on domestic, but also on transboundary level. Some of the countries analyzed in this study such as the US, Turkmenistan, Uzbekistan, or Kazakhstan, possess oil and gas reserves and may tend to focus on hydrocarbon resources for generating electricity, while the other countries, such as Tajikistan, Kyrgyzstan, Ethiopia, or Laos, have to lean on hydroelectricity or electricity trade. On the other hand, some countries choose to focus on hydroelectricity generation as parts of their energy policy. China, Canada, and the US are among the top ten oil producers globally. At the same time, these countries rank first, third and fourth among the largest hydropower producers globally.[1586]

[1586] World Energy Council, "Energy Resources - Hydropower," *worldenergy.org*, 2016, available at: https://www.worldenergy.org/data/resources/resource/hydropower/ (accessed 5 October 2017).

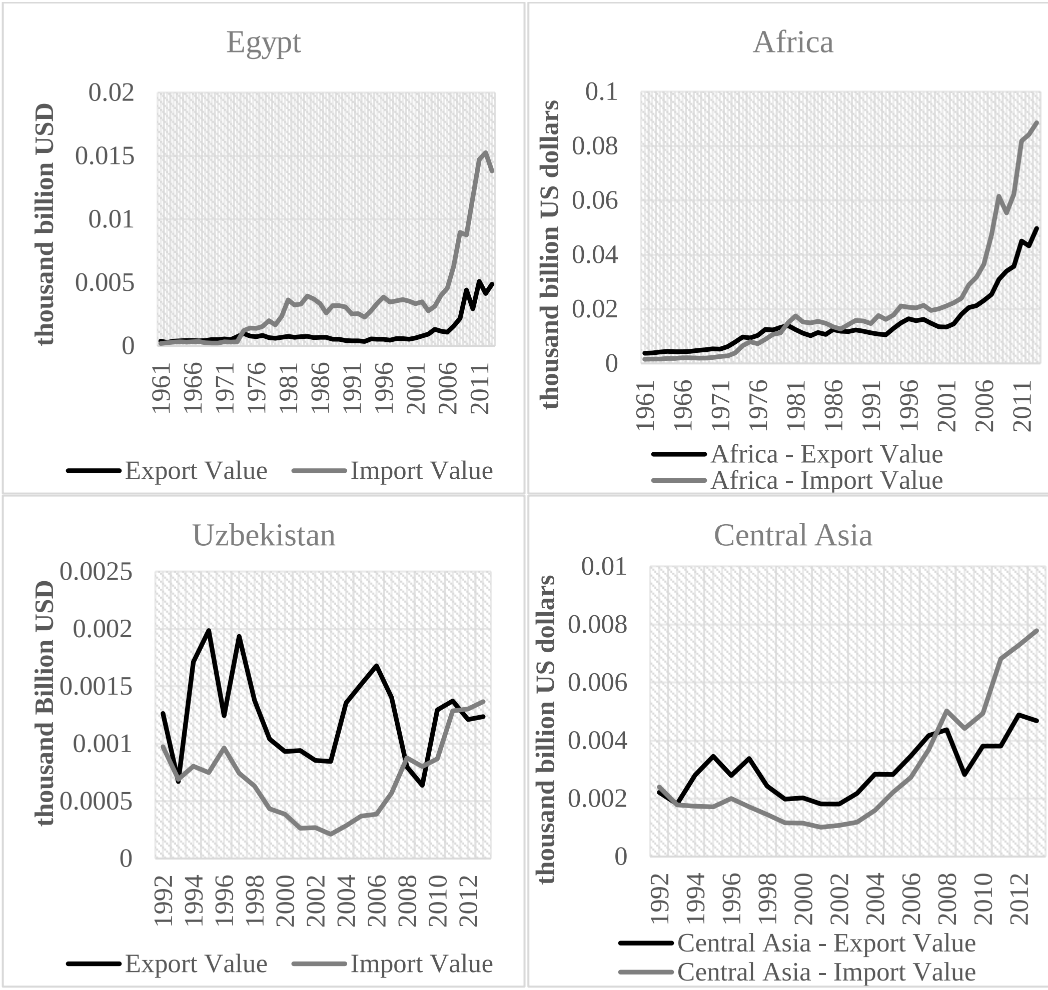

Figure 8.6. Agricultural products trade values of selected regions[1587]

While some of the hydropolitical problems between the riparians are direct consequences of economic (agricultural, hydropower) problems like in the cases of the US and Mexico, Uzbekistan and Kyrgyzstan and Tajikistan; in other cases, technical or engineering problems may turn into political problems between states, most notably in Chinese upstream development projects. In some cases, such as the riparian relationship between the US and Mexico in the Colorado River basin, the

[1587] Food and Agriculture Organization of the United Nations, "Crops and Livestock Products," *FAOSTAT*, 2017 (Last updated: 9 February 2017), available at: http://www.fao.org/faostat/en/#data/TP (accessed 16 August 2017).

upstream countries may use their advantageous geographical position in combination with their political and economic power, and in some cases, the downstream countries may use their political power along with their historical legal rights and traditional practices. The typical example of such a case is Egypt's relationship with its upstream neighbors, especially with Ethiopia.

Inundation of large fertile agricultural zones, relocation of thousands of people, ecosystem degradation, sedimentation, and salinization are among the numerous impacts caused by large projects. Governments and international development agencies often venture the consequences of these risks and initiate large engineering projects often for generating and exporting cheap hydroelectricity to boost economic development. Large HPP projects of the governments may cause transboundary disputes if these impacts are likely to occur in one or more riparian countries. These differences often tend to be resolved through negotiation and through the implementation of bilateral or regional environmental agreements.

However, the dispute is tougher to settle if the water demanded for upstream hydropower generation may result in decreased water supply in downstream countries. In such cases, the existence of international agreements or regimes do not suffice. In addition, if the economy of the downstream nation is entirely or mostly dependent on agricultural activity (Figure 8.2 and Figure 8.4), the dispute gets an international character that often leads to a diplomatic deadlock between the countries. Among the most notorious of such kind of debates are those in the Aral Sea basin, in the Nile River basin, or in the Mesopotamia. Decreasing the dependence on agricultural activity, as well as abandoning the insistence on the policy of agrarian self-sufficiency (increasing the volume of virtual water trade), as observed partly in the case of Egypt, may contribute to the solution of problems.

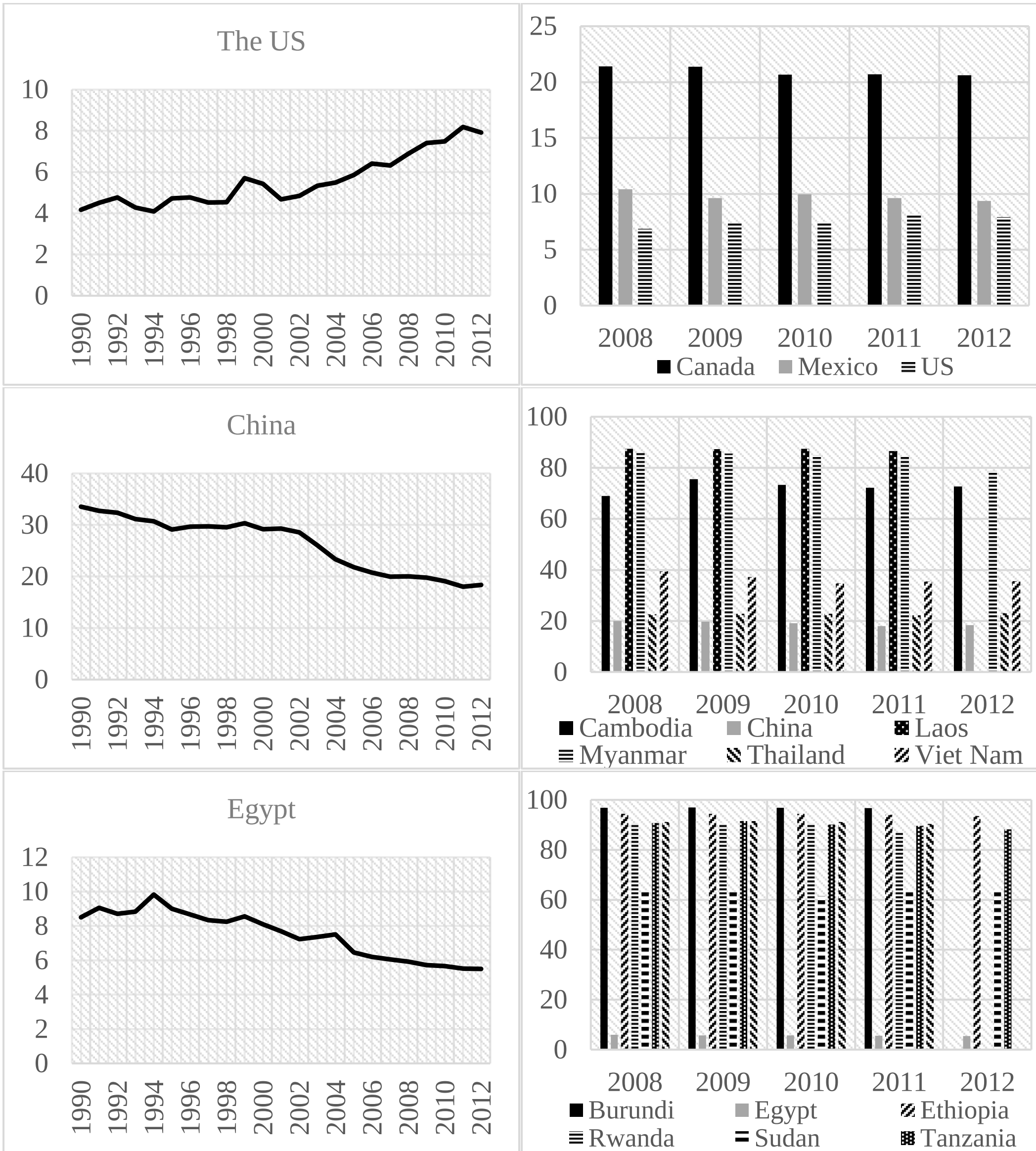

Figure 8.7. Renewable share in total energy consumption in selected countries[1588]

Intra-basin hydropower trade may be an important element for boosting the solution processes of hydropolitical disputes. This study scrutinizes some key river basins

[1588] United Nations, "Renewable energy share in the total final energy consumption," *UN Data*, 2016, available at: http://data.un.org/Data.aspx?q=energy&d=SDGs&f=series%3aEG_FEC_RNEW (accessed 29 November 2016).

in this respect. In some regions of the world, the scope of electricity pools and common grids are increasing. For instance, the largest bilateral electricity trade takes place between the US and Canada. The US imports a significant amount of electricity from its neighbors. As of 2013, it imported 63.6 TWh and exported 11.3 TWh, over 95 percent of this trade volume being with Canada. Although the imported electricity meets only 1 percent of total electricity demand and remains marginal in comparison to the electricity produced,[1589] in absolute terms, this is a significant amount. The imports of the US reached to 71 TWh, while Canadian exports reached to 55 TWh in 2016.[1590] Canada ranks first among five top electricity exporting countries in the world as of 2016[1591] and exports about 10 percent of its total capacity of generation. In the West, however, the provinces of Canada are often net importers, as the US has large HPPs especially in Washington, such as the Grand Coulee or the Chief Joseph in the Columbia River basin. The volume of electricity trade depends on various factors from domestic industrial demand to difference of prices.[1592] The trade volume of the US with Canada is far larger than the volume with Mexico. This shows that the regional electricity integration in North America is lower than intended,[1593] despite the presence of long-established regional bodies encouraging regional trade, such as the NAFTA, since 1994.

[1589] International Energy Agency, *Energy Policies of IEA Countries: The United States*, IEA, 2014, p.42.

[1590] Enerdata, "Electricity Trade," *Global Energy Statistical Yearbook*, 2016, available at: https://yearbook.enerdata.net/electricity/electricity-balance-trade.html (accessed 12 October 2017).

[1591] Enerdata, "Electricity Trade," *Global Energy Statistical Yearbook*, 2016, available at: https://yearbook.enerdata.net/electricity/electricity-balance-trade.html (accessed 12 October 2017).

[1592] International Energy Agency, *Energy Policies of IEA Countries: Canada*, IEA, 2015, pp.173-74.

[1593] Pierre-Olivier Pineau, Anil Hira & Karl Froschauer, "Measuring International Electricity Integration: A Comparative Study of the Power Systems under the Nordic Council, MERCOSUR, and NAFTA," *Energy Policy*, vol. 32, 2004.

In the case of China, one may generally observe that the economic growth in the Southeast Asia is remarkable, and the electricity demand is growing.[1594] The main centers of electricity demand in the region are Thailand, Viet Nam, China, and India. The source of demand in Viet Nam, Thailand and China is rapidly developing industrial sectors. Electricity generation is also increasing in the region. The second largest economy in the world, China, has energy self-sufficiency and is a net electricity exporter. Furthermore, the Chinese government seeks to export excess electricity to the downstream riparians in the Mekong River basin. Therefore, for the less developed nations, Laos and Cambodia, the best opportunity seems to be Viet Nam and Thailand in the short to medium term. The interconnectivity in the Mekong region was impacted by the regional politics as in the other cases. Currently, the electricity connection remains on lower levels, but there are projects to bolster regional power trade through the construction of new and better transmission lines. The financial support from China and international donors and development agencies, as well as the Chinese government's association of these interconnection projects with the popular "One Belt One Road" initiative turns the realization of these projects into more realistic regional integration plans.

One of the hotspots in the One Belt One Road initiative of China is Central Asia. The fertile valleys and plains of Central Asia are located mostly within the boundaries of the downstream countries in the Aral Sea basin. Tajikistan and Kyrgyzstan, the upstream countries, are the source of the most of the water in the Aral Sea basin. Their mountainous geography do not allow them to conduct large scale irrigated agriculture, but it contributes their hydropower potential, and the governments of these countries desire to exploit this by installing new and large dams with high hydropower generating capacity turbines. During the Soviet era, a well-planned system was in operation, in which the seasonal power demands of the upstream was met by the downstream and a barter mechanism was in place—water was traded in

[1594] International Energy Agency, *Southeast Asia Energy Outlook*, EIA, 2015, pp.21-22.

return for energy. The regionally integrated electricity grid with a center in Tashkent, the CAPS, was part of this mechanism. However, after the end of the planned era, the system collapsed. Since 1990, power trade through the CAPS declined more than 90 percent. Among the CAPS countries, the greatest electricity consumer is Uzbekistan. Despite the new HPP and TPP development projects of the downstream countries, especially those of Uzbekistan and Kazakhstan, projections show that there will be supply gaps for these countries in the near future. The supply can well be met by the new upstream HPPs that would be connected to the CAPS, but the political situation in the region has not permitted such an integration thus far. Another major obstacle for the electricity integration in the region is the energy self-sufficiency policies of the regional countries, in parallel to the unpleasant regional political atmosphere. On the other hand, the lack of maintenance in the aged transmission lines in Central Asia may also hinder the healthy transfer of electricity. Regional energy integration within the Central Asian states is not the only option for the upstream countries in the Aral Sea basin. The landlocked region has other options of delivering excess electricity through land routes to other neighboring countries, such as towards Afghanistan and Pakistan, as well as towards China. Since 2006, some international donors and organizations, such as the ADB and the World Bank, support the CASA-1000 project that is intended to dispatch planned excess electricity from the HPPs of Tajikistan and Kyrgyzstan to their southern neighbors through new transmission lines.[1595] Also, the Chinese electricity companies have projects of connecting Tajikistan and Kyrgyzstan national electricity grids to the west of China.[1596] Without doubt, regional politics is being involved and will be involving in the power trade in Central Asia.

For the Nile River basin, hydroelectricity was not an issue for ages. The main subject was regulating the Nile water for irrigating the fertile delta. Egypt was the focal

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[1595] Vladimir Yasinskiy, Alexander Mironenkov & Tulegen Sarsembekov, *Modern Water Management in the CIS Countries* (Almaty: Eurasian Development Bank, 2014), pp.169-71.

[1596] Muhamad Olimat, *China and Central Asia in the Post-Soviet Era: A Bilateral Approach* (Lanham: Lexington Books, 2015), pp.139-40.

point in this picture, which was dominated by imperial powers until recently, and became the most developed nation in the Nile River basin. But the picture has been in a steady change since hydroelectricity became a subject on the regional agenda and the upstream countries recorded economic growth and demanded more energy. Now, Sudan demands more water for irrigation, while Ethiopian government desires to exploit the potential of the huge runoff of the Nile River. Under these circumstances, the desire of the Ethiopian government to produce more hydroelectricity is the key point of the hydropolitical relationship in the river basin, along with the Sudan government's desire to irrigate more lands. Similar to the relationship between the upstream and downstream in Central Asia, Egypt has long asserted political and even military influence over the riparians, but the situation is prone to change under recent political developments in the region, which also affected Egypt in the early 2010s. After the construction of the new HPPs, the Ethiopian government desires to export excess electricity to the Sudan, the second largest economy and the second largest demand center in the Nile River basin. To realize electricity export aims, the Ethiopian government plans to build new transboundary transmission lines towards the Sudan. Ethiopian electricity will also be exported to Kenya and Djibouti as well.[1597] The presence of the EAPP under the Common Market for Eastern and Southern Africa is a major opportunity for bolstering regional electricity trade within the Nile River basin. Although currently there are no physical electricity connections between Egypt and the other riparians some transmission lines are being planned since 2012 between Egypt and the Sudan, which indirectly connects the Ethiopian grid to the Egyptian grid. On the other hand, Egypt continues to occasionally oppose the upstream HPP projects and therefore the future of energy interconnection is dependent on regional politics.

This study scrutinizes the models of hydropolitics and electricity trade nexus in various regions from around the globe. It assesses North America, where the largest bilateral electricity trade takes place on one hand, and on the other, it investigates

[1597] REN21, *Renewables 2017 Global Status Report*, Renewable Energy Policy Network for the 21st Century, 2017, p.57.

the case of Egypt, which is highly dependent on the Nile waters but has no interconnections with the riparians. In many regions of the world, new common grids are planned or under construction, and the volume of global electricity trade is increasing. In the case of the US, high volumes of electricity trade along with strong economic ties in the north contribute to the solution of transboundary water problems, while water scarcity and underdeveloped electricity trade exacerbates bilateral water problems in the south. Some other factors, such as the climate, hydropower potential, and political history may play decisive roles here, and to reach a sounder conclusion, similar cases are investigated. In that respect, China is comparable to the US case in terms of the size of economy, electricity consumption, hydropower installed capacity, water withdrawals, and being upstream in key southern transboundary river basins. In the eleven riparians south of China, economic activity and population density is higher compared to the north. Although the unilateral water development projects and policies in the upstream of the southern transboundary rivers of China are severely criticized, some riparians see the infrastructure investments of China into the hydropower sector as an opportunity for regional electricity trade and increased economic integration. In that respect, the increased electricity trade in South and Southeast Asia may play a decisive role in the solution of transboundary water problems. As both China and the US are dominant (mostly) upstream powers sharing a significant number of transboundary waters with neighbors, other less dominant powers and downstream countries in key river basins are also included in this study for completing a healthy comparison. The case of Kyrgyzstan is indicative here as it is a non-dominant riparian in one of the key transboundary river basins in the world. In Central Asia, the agricultural sector in the downstream riparians in the Aral Sea basin withdraws most of the freshwater. The barter mechanisms of the Soviet era, including the common grid known as the CAPS, remained on paper after the dissolution of the Soviet Union. Water-related political problems in the region increased with the decrease in the volume of regional electricity trade. On the other hand, the presence of an already existing system may be a starting point for the resurrection of the regional electricity integration in short to medium term, which, in turn, may facilitate the solution of water–related problems based on cooperation and interdependence in the region. While the case of Kyrgyzstan shows the importance of electricity trade in the presence of a non-dominant upstream riparian in a key river basin, the case of Egypt is indicative for a dominant downstream that is dependent on a single transboundary river basin. Egypt has no transboundary electricity connections with the Nile river basin countries, and the upstream countries have long been investing in large hydropower schemes and their electricity generation capacity has increased. There are plans of connecting Egypt to the EAPP common grid, and this is expected to increase cooperation among the Nile basin countries.

Basin-wide electricity trade is often suggested as a strategy to facilitate the resolution of water-related problems through increasing regional economic interdependence with technical means. In almost all regions scrutinized in this study, there is either an existing infrastructure, or comprehensive plans for building transboundary electricity transfer lines. International organizations support most of these projects. Despite the presence of complicated and long drawn out water-related problems between the riparians, energy trade relations tend to be milder and may develop unexpectedly faster. This interdependence is beneficial for achieving regional electricity supply security and engendering foreign exchange flows to less developed countries within river basins. A comparative analysis of these models confirms the hypothesis that electricity trade and the severity of the transboundary water management problems in the key river basins are closely related. This is valid for both developing and developed countries.

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APPENDICES

Appendix A: Turkish Summary / Türkçe Özet

Bu çalışmanın ana konusu önemli uluslararası nehir havzalarında iktisadi faaliyetin su yönetimi, hidroelektrik enerji üretimi ve elektrik ticaretini nasıl etkilediği ve bunlardan nasıl etkilendiği meselesidir. Çalışmada analiz birimi olarak sınırları modern siyasi hudutlarla belirlenen devletler ele alınmıştır. Ancak daha geniş manada sınırları coğrafya tarafından belirlenen nehir havzaları da örnek ülkeler ile ilişkileri, örnek ülkelerin iktisadi faaliyeti üzerindeki etkileri ve kıyıdaş ülkeler arası hidroelektrik ticaretindeki rolleri bağlamında bu çalışma kapsamında değerlendirilmektedir. Enerji ticareti bağlamında ise temel odak noktası kıyıdaş ülkeler arasındaki ikili elektrik ticareti olmakla birlikte, bu tartışmayı tamamlayıcı olarak havza genelinde gerçekleşen bölgesel elektrik ticareti de gündeme getirilmektedir.

Çalışmanın cevaplamaya çalıştığı araştırma sorusu, ülkeler arası su yönetimi politikaları ile ülkeler arası ikili elektrik ticareti arasında nasıl ve ne yönde bir bağlantı olduğu sorusudur. Test edilen başlangıç hipotezi, belli bir sınır aşan nehir havzası içinde yer alan siyasi birimler arasındaki hidroelektrik enerji ticareti veya paylaşımının seviyesi ile kıyıdaşlar arasında su kaynaklı ve ekonomik temelli ikili sorun alanlarının sayısı ve şiddeti arasında iki yönlü ve ters bir ilişki olduğu yönündeki hipotezdir. Çalışmanın bulguları genel olarak bu hipotezi doğrulamaktadır.

Bu çalışmanın temel varsayımı, önemli nehir havzaları dâhilinde, kıyıdaş ülkeler arasındaki iktisat temelli sorun alanlarının ve meselelerin şiddetini ve sayısını artıran veya azaltan, aynı zamanda da komşu iki ülke arasında gerçekleşen hidroelektrik enerji ticaretinin seviyesi üzerinde belirleyici olan bazı unsurlar olduğudur. Bunlar arasında incelenen bölgelerin coğrafi yapısı başta olmak üzere, kurumsal ve yasal çerçeve, bölgelerin ve ikili ülkelerin siyasi tarihsel gelişimleri gibi unsurlar önemli yer tutmakla birlikte, nehir havzaları genelindeki iktisadi faaliyetin yapısı ve büyüklüğü de kritik öneme sahiptir. Bu varsayımlar çerçevesinde çalışmada temel alınan odak noktası, su yönetimi, iktisadi kalkınma, elektrik üretimi ve su siyaseti açısından belirleyici rol oynayan ve bürokrasi ve siyasetçiler gibi karar alma mekanizmaları açısından önemli ve geniş kullanımlı araçlar olan sulama ve elektrik üretimi amaçlı barajların ekonomik açıdan incelenmesidir. Çalışma, Giriş ve Sonuç bölümleri dâhil sekiz bölümden oluşmaktadır. Giriş bölümünü takip eden iki bölüm, çalışmanın temel meselesini teorik çerçevede değerlendirirken, konu ile ilgili yapılan çalışmaların sistematik bir analizini de sunmaktadır. Teorik bölümleri takip eden bölümler ise çalışmada değerlendirilen ülke örneklerinin incelenmesidir.

İkinci bölüm, "Teorik Yaklaşımlar" başlığını taşımaktadır. Bu bölüm, çalışmanın esas meselesini teorik seviyede değerlendirmekte ve çalışmanın konusunu ilgilendiren, farklı bağlamlarında yapılmış bulunan çok sayıda teorik ve ampirik çalışmayı analitik bir literatür taraması çerçevesinde ele almaktadır. Bu bağlamda ilk bölümde hem su, hem de hidroelektrik ve çevre konuları Uluslararası İlişkiler disiplininin temel çerçevesi dâhilinde kalınmaya çalışılarak incelenmektedir. Temel olarak, su, su kıtlığı, güç ve çatışma konuları arasında bağlantı kurmaya çalışan yaklaşımlar, Uluslararası İlişkiler bağlamında yeni-Malthusçu bir realizmden etkilenmektedirler. Bu alanda yapılan çalışmalar, su kıtlığı mefhumu ile bir nehir havzası dâhilindeki ülkeler arasında yaşanan siyasi ve ekonomik temelli uyuşmazlıklar arasında doğru yönlü bir ilişki olduğunu savunmaktadırlar. Bu çerçevede nehir havzası temelli su sorunları, ülkeler arasında topyekûn bir savaşa neden olmasa bile, silahlı çatışmaya varabilecek uzlaşmazlık alanları doğurmaya namzettir. Özellikle iklim değişikliğinin yıkıcı etkileri nedeniyle, dünyanın su açısından zengin olmayan ancak nüfus yoğunluğu ve iktisadi faaliyet bağlamında suya bağımlı bölgelerinde su kaynaklı siyasi gerilimin artma ihtimali görece daha yüksek bulunmaktadır. Diğer taraftan, sınır aşan nehir havzaları bağlamında kurumlar, rejimler ve ülkeler arası iş birliği konuları üzerine yoğunlaşan çalışmalar realizm temelli karamsar senaryoların aksine iyimser bir bakış açısına sahiptir. Bu alanda çalışan akademisyenler, ülkeler arası sınır aşan nehir havzaları bağlamında, su konularının çatışmaya değil, karşılıklı bağımlılık çerçevesinde bölgesel iş birliğine, iktisadi faaliyetin ve ticaretin gelişimine katkı sağlayacağı düşüncesinden yola çıkan ve liberal Uluslararası İlişkiler teorilerinden etkilenen çalışmalar yapmaktadırlar. Küresel ve bölgesel sivil toplum kuruluşları ile uluslararası organizasyonların da desteklemesiyle, uluslararası alanda kabul görmüş nehir havzası yönetim prensiplerinin uygulanması, önemli ve geniş sınır aşan nehir havzaları için tarım, enerji üretimi ve su kullanımı alanlarının her birinde optimum ve sürdürülebilir gelişimin ve iktisadi kalkınmanın temellerini oluşturmaktadır. Bununla birlikte, iklim değişikliği, kuraklık, nüfus artışı, ekonomik büyüme ve bunlara bağlı olarak artan su talebi sebepleriyle su kaynakları üzerinde artarak yoğunlaşan baskıdan kaynaklanan problemlerin tek ve en iyi çözümünün uluslararası rejimler, Bütünleşik Su Kaynakları Yönetimi ve Nehir Havzası Yönetimi gibi uygulamaları temel alan yaklaşımların teorik çerçevesinde ele alınması gerektiği yönünde yaygın bir anlayış söz konusudur. Bütünleşik Su Kaynakları Yönetimi, Su Yönetişimi gibi kavramlar, sınır aşan su kaynaklarının uluslararası anlaşmalar ve rejimler çerçevesinde nehir havzası temelli bir bakış açısı ile tüm paydaşların sürdürülebilir ekonomik büyümelerini ve ekolojik dengeleri gözeten bütüncül bir yaklaşımla yönetilmelerine yönelik ilkeleri içeren teorik düzeyde önemli yol göstericiler niteliğindedir. Yine de, bu kavramların neyi ifade ettiği, evrensel uygulanabilirliği ve gerçekten gözle görünür sonuçlar üretip üretmedikleri yönünde ciddi tartışmalar da mevcuttur. Nitekim literatürde, hem su temelli çatışma, hem de su temelli iş birliği alanlarında yapılan çalışmalara yöneltilen ciddi eleştiriler bulunmaktadır. Bu eleştirilerin bir kısmı, mevcut literatürün hidroloji ve su alanlarında yaşanan değişimi açıklamada yetersiz kaldığı yönündedir. Ayrıca, devletlerin ürettiği bilginin veri olarak kullanılması ve bu şekilde bir analiz yapılarak sonuçlara varılması da literatürdeki çalışmalara yöneltilen eleştiriler arasındadır. Siyasi açıdan taraflı olabilecek bu bilgi kaynağı yerine yerel bilgiye önem verilmesini öneren çalışmalar bu eleştirilerin odak noktasını oluşturmaktadır. Tüm bu tartışmaların yanında, konuyu daha çok teknik bağlamda ele alan ve su-enerji, su-gıda-enerji gibi alanlarda karşılıklı bağımlılığı inceleyen çalışmalar, su ve enerji konularının birbirinden bağımsız değerlendirilmemesi gerektiğini savunmaktadır. Bu çerçevede, enerji üretimi sırasında belli miktarda suya ihtiyaç duyulduğu gibi, su yönetimi, arıtma, sulama ve benzer faaliyetler esnasında da belli miktarda elektrik enerjisi tüketilmektedir. Bu karşılıklı bağımlılık, su ayak izi alanında yapılan çalışmalarda ifade edilmektedir. Buna göre, her türlü sanayi üretimi, elektrik üretimi, gıda ürünleri üretimi gibi faaliyetler esnasında tüketilen su, bu faaliyetler sonucunda ortaya çıkan ürünlerin su ayak izini vermektedir. Su ayak izi temelli yaklaşımlar, artan su talebi ve su kullanımı konularında farkındalığın artarak yüksek su talep eden ürünlerin talebini kısıtlayabilmektedir. Bununla birlikte, teknik düzeyde olan bu karşılıklı bağımlılığın iktisadi ve siyasi bir boyutu da bulunmaktadır. Bu çalışma, bu karşılıklı bağımlılığı siyaset ve ekonomi bağlamına taşıyarak su yönetimi uygulamalarının hidroelektrik ticareti üzerindeki etkileri ile hidroelektrik ticaretinin kıyıdaş ülkelerin su kaynaklı siyasi meseleleri üzerine etkilerinin bir bütün olarak ele alınması gerektiğini savunmaktadır. Hidro-hegemonya ve güç temelli yaklaşımlar konunun iktisadi boyutunu göz ardı ederken, kurum ve rejim temelli iş birliği yaklaşımları kavramsal çerçevenin ötesine geçmekte zorlanmaktadırlar. Bu nedenle, belirli sınır aşan nehir havzalarında su yönetimi ve hidroelektrik ticareti modelleri karşılaştırmalı olarak incelenerek genel kavramsal çıkarımlar yapmak ve uygulama önerileri geliştirmek bu çalışmanın temel öncelikleri arasındadır.

Çalışmanın üçüncü bölümü, "Su ve Elektrik Ticareti" başlığını taşımakta ve konuyu iktisadi açıdan ele almaktadır. Bu çerçevede bu bölüm, çalışmanın temel araştırma konusu bakımından kritik konular olan su talebi, su arzı ve sanal su ticareti gibi konuları tartışmaktadır. Tüm dünyada su ve su yönetimi uygulamaları, devletler ve uluslararası kuruluşlar tarafından kalkınma ve iktisadi büyümede temel öncelikli alanlar olarak belirlenmiştir. Buna paralel olarak büyük ve önemli sınır aşan nehir havzalarında geniş tarım arazileri sulamaya açılmış ve büyük nehirler üzerine barajlar inşa edilmiştir. Bu yaklaşım çerçevesinde yürütülen projeler geniş çaplı ve yüksek maliyetli projeler olmaları nedeniyle devletler, devletlerin yetersiz kaldığı durumlarda ise uluslararası kalkınma ajansları ve örgütleri tarafından finanse edilmiştir. Birçok durumda ise devletler, geniş bürokratik mekanizmalar oluşturarak su ve baraj projelerine birinci elden müdahil olmuşlardır. İktisadi kalkınma, artan nüfus ve sanayi üretimi, yeni tarım alanlarının açılması ve sulu tarıma yönelik yoğun talep ile birlikte çevresel su ihtiyacı gibi faktörler çerçevesinde istikrarlı biçimde artan su talebine karşılık verebilmek için devletler, su arzını artırmaya yönelik faaliyetlerin yanında, su talebini sınırlamaya yönelik uygulama ve politikalara yoğunlaşmaktadırlar. Son yıllarda artan çevre bilinci ile birlikte su ve çevre konularının siyasi açıdan ele alınma biçimlerinin değişmesi neticesinde genel eğilim, su arzını artırıcı önlemler yerine su talebini sınırlayıcı politikalar geliştirme yönünde olmaktadır. Bu noktada sulu tarım ve tarım ürünlerinin uluslararası ticareti gündeme gelmektedir. Sanal su ticareti olarak özetlenen bu uygulama neticesinde ülkeler, yüksek miktarda su gerektiren tarım ürünlerini kendi sınırları dâhilinde üretmek yerine diğer ülkelerden satın alırlarsa, bu tarım ürünlerinin üretimi sırasında tüketilen suyu da satın almış olmaktadırlar. Bu manada sanal su ticareti, özellikle su kıtlığı, kurak iklim ve iklim değişikliği gibi faktörlerden etkilenme olasılığı yüksek olan su bağımlı bölgeler için ciddi ve sürdürülebilir bir politika aracı olarak ortaya çıkmaktadır. Dolayısıyla, su konusunda sıkıntılar yaşayan ülkelerin gıda konusunda kendi kendine yetme gibi üniter politikalar yerine sanal su ticareti temelli tarım ürünleri ithalatı seçeneğini değerlendirmeleri, dünya genelinde su kaynakları üzerinde giderek artan baskıyı azaltmaya yönelik önemli bir adım olabilir. Diğer taraftan su, yalnızca tarım ürünleri üretimi maksatlı değil, aynı zamanda, başta hidroelektrik üretimi olmak üzere çok çeşitli ve çoğu zaman birbirini dışlayan maksatlarla talep edilmektedir. Bunun örnekleri sınır aşan önemli nehir havzalarında sıklıkla gözlenmektedir ve bu çalışmada ele alınan vakalardan bazıları bu ikilemin tipik örneklerini oluşturmaktadır. Bu nedenle su yönetimi, arzı, talebi ve ticareti yanında, hidroelektrik üretimi ve ticaretinin ele alınarak analize dâhil edilmesi önem arz etmektedir. Dünyada 2015 yılı itibariyle hidroelektrik kurulu gücü 1200 gigawatt değerini aşmıştır. Son yıllarda, özellikle Çin, Brezilya ve Türkiye gibi ülkelerin yoğunlaşarak artan hidroelektrik yatırımları söz konusudur. Dünya Bankası verilerine göre, dünya genelinde 2013 yılı sonu itibariyle su kaynaklarından üretilen elektrik enerjisi, toplam elektrik üretiminin yüzde 16'sina tekabül etmektedir. Gelişmekte olan ülkelerin yoğun baraj ve hidroelektrik üretimi yatırımlarına rağmen, dünyada büyük barajlar ve geniş kapsamlı su yönetim projeleri sürdürülebilirlik tartışmalarını beraberinde getirmektedir. Birçok ülkede büyük barajlar yenilenebilir enerji kapsamından çıkartılarak baraj inşasına verilen siyasi ve mali destek bilhassa gelişmiş ülkelerde giderek azalmaktadır. Ancak yine de ağırlıklı olarak gelişmekte olan ülkelerin siyasetçileri ve bürokratları baraj ve hidroelektrik projelerine ağırlık vermekte, barajlarda üretilen enerjinin fazlasını komşu veya yakın çevredeki ülkelere satarak gelir elde etmeye, kalkınma ve büyümeyi hızlandırmaya ve bu yatırımlardan siyaseten faydalanmaya yönelmektedirler. Elektrik ticareti dünyanın bazı bölgelerinde yoğunlaşmakla birlikte birçok bölgede yeni altyapı yatırımları sayesinde ortak elektrik ağları ve enerji havuzları oluşturulmakta ve elektrik enerjisi ticaretinin miktarı ve genişliği giderek artmaktadır. Çalışmanın dördüncü, beşinci, altıncı ve yedinci bölümlerinde dünya üzerinden örneklerle su yapıları, projeleri, su sorunları ve hidroelektrik üretimi ile ticareti arasındaki bağlantıları konu alan modeller incelenmektedir.

Dördüncü Bölüm, Amerika Birleşik Devletleri'nin (ABD) sınır aşan nehir havzaları çerçevesinde önemli su meseleleri ile hidroelektrik ticareti arasındaki bağlantıyı incelemektedir. Kuzeyde Kanada, güneyde Meksika ile sınır komşusu olan ABD, kuzeyden güneye doğru değişen iklim ve kuraklık koşullarına sahiptir. Kanada ile paylaşılan çok sayıda ve zengin su kaynakları arasından Columbia, Nelson-Saskatchewan ve Great Lakes büyük ve önemli nehir havzalarını oluşturmaktadır. Bunlar arasından Columbia nehri, en batıda yer alan ve kaynağı Kanada'da bulunan, yaklaşık 2000 kilometre uzunluğunun bir kısmı ABD ile Kanada arasında sınır oluşturan bir nehirdir. Bu nehir havzasının en önemli özelliği, hidroelektrik üretim kapasitesinin çok yüksek olması ve ABD'deki en büyük barajların bu havza dâhilinde yer almasıdır. Daha doğuda, Great Lakes göller sistemi, birbirine nehirlerle bağlantılı göllerden oluşmakta ve Saint Lawrence nehri yoluyla Atlantik Okyanusu'na boşalmaktadır. Bu havzalarda su kıtlığı önemli bir sorun olarak ortaya çıkmamakla birlikte kirlilik ve diğer çevre sorunları gündemde yer almaktadır. Güneyde ise Colorado ve Rio Grande nehirleri Meksika ile ABD arasında paylaşılan büyük su kitleleridir. Bunlardan yaklaşık 3000 kilometre uzunluğundaki Rio Grande, ABD'de Colorado eyaletinin güneyinde yer alan San Juan Dağlarından kaynağını alır ve San Luis Vadisi ve Albuquerque Vadisi gibi önemli sulama alanlarından geçerek El Paso'dan Meksika sınırlarına girer. Colorado Nehri ise yaklaşık 2300 kilometre uzunluğundadır ve Rocky Dağlarından kaynağını alır. Coloradoo

Nehri havzasının yüzde 97'si ABD sınırları dahilinde olmasına rağmen Meksika'nın bu nehre ciddi ekonomik bağımlılığı vardır. Bu bölgede uzun yıllardan beri görülen kuraklık, iklim değişikliğinin yıkıcı etkileri ile birlikte ciddi su sorunlarına yol açmaktadır. ABD'nin tüm nehir havzalarında memba pozisyonunda olması, siyasi ve ekonomik olarak güçlü olan bölgedeki konumunu hidropolitik açıdan da güçlendirmektedir. ABD'de batı eyaletlerinin nüfus ve iktisadi açıdan gelişiminin büyük nehir havzalarından istifade edilmesi süreci ile bağlantılı bir tarihsel gelişim çerçevesinde seyrettiği göz önünde bulundurulduğunda, ABD'nin memba konumunun avantajını kullanarak Rio Grande ve Colorado nehirlerinin sularını yoğun tarımsal üretime yöneltmesinin su kaynakları üzerindeki baskıyı artırdığı düşünülebilir. Bu baskıları azaltmak ve sınır aşan su yönetimini düzenlemek için Uluslararası Sınır ve Su Komisyonu kurulmuş ve 1944 yılında bu komisyonun yapısı ve görevleri güncellenmiştir. Bunun yanında, ABD sınırları dâhilinde kuraklıkla mücadele için Kuraklık Su Bankası dâhil olmak üzere su talebini yönetmeye yönelik tedbirler alınmıştır. Ancak tarihsel seyre bakıldığında Batı'daki nehirlerin su miktarının azaldığı, Colorado nehrinin okyanusa ulaşamadığı görülmektedir. Artan nüfus, iktisadi büyüme ve kuraklık koşulları altında artma eğiliminde olan su talebi, yönetilmesi zor ve bölgesel bir sorun halini almıştır. Kuzeyde yoğun bir şekilde gerçekleşen hidroelektrik ticareti ile birlikte güçlü ticari ve iktisadi ilişkiler su sorunlarının çözümünde olumlu etkide bulunurken, güneyde su kıtlığı ve hidroelektrik ticaretinin görece düşük seyri yanında zayıf siyasi ve ticari ilişkiler su sorunlarının çözümünde olumsuz etki yaratmaktadır. Elbette kuzey ve güney arasındaki iklim, hidroelektrik potansiyeli, siyasi tarih gibi alanlarda gözlenen farklılıklar da su projeleri ve su sorunları üzerinde etkili olmaktadır. Bu analizde hidroelektrik ticaretinin yerini ve ağırlığını daha sağlıklı olarak belirleyebilmek için farklı ülke ve bölge ülkelerini de değerlendirmek gerekmektedir. Bu nedenle su projeleri ve hidroelektrik konularında dünyanın en iddialı ülkelerinden Çin'deki durum bu çalışma kapsamında incelenmektedir.

Dünyanın en büyük ikinci ekonomisi konumunda olan Çin, su ve hidroelektrik konularında ön plana çıkmaktadır. Çok sayıda komşusu ile çok farklı iklim, coğrafya ve beşeri koşullarda çok sayıda sınır aşan nehir havzası paylaşan Çin, hidropolitik ve su yönetimi açılarından dünyanın en karmaşık ülkesi gibi görünmekle birlikte, temel su meseleleri bağlamında benzer sorunların yaşandığı nehir havzaları dahilinde yer almaktadır. Bu anlamda Çin'in komşuları ile paylaştığı nehir havzalarını su kıtlığının, iktisadi faaliyetin ve nüfus yoğunluğunun görece düşük olduğu kuzeydeki sınır aşan nehir havzaları ve nüfus ve iktisadi faaliyetin yoğunlaştığı güneydeki nehir havzaları olarak ikiye ayırmak mümkündür. Kuzeyde Rusya, Moğolistan ve Kuzey Kore ile paylaşılan önemli nehirler, Amur (Heilong), Yalu (Amnok) ve Tümen nehirleridir. Bunlardan 4400 kilometre uzunluğundaki Amur nehrinin havzası, Çin ve Rusya arasında neredeyse eşit oranda paylaşılmakta, Tümen ve Yalu nehirleri ise Kuzey Kore ile Çin arasındaki sınırı oluşturmaktadır. Burada düşük nüfus yoğunluğu ve su bolluğu, neredeyse hiçbir ciddi sınır aşan su sorununun yaşanmaması ile sonuçlanmaktadır. Güneyde ise Tibet Platosu'ndan kaynaklanan Mekong, Salween, Irrawaddy, Brahmaputra ve İndus gibi nehirler, on bir ülke ile paylaşılmaktadır. Bunlar Viet Nam, Laos, Myanmar, Kamboçya, Tayland, Bangladeş, Butan, Nepal, Hindistan, Pakistan ve Afganistan'dır. Güneydeki nehirler arasında Mekong, Ganj-Brahmaputra-Meghna havzası ve İndus nehirleri iktisadi ve hidropolitik açılardan öne çıkan nehir havzalarıdır. Çin sınırları dahilinde Lancang olarak anılan Mekong Nehri, Tibet Platosu'ndan kaynağını alır. Nehrin Çin sınırları içinde kalan kısmı hidroelektrik üretimine çok müsaittir. Mekong Nehri Güneydoğu Asya'daki ülkeler arasında sınır oluşturması açısından da önemli bir nehirdir. Bu nehrin havzası, Güneydoğu Asya'nın neredeyse üçte birini kapsamaktadır ve bölgedeki iktisadi faaliyet bu nehir havzasında yoğunlaşmıştır. Ganj-Brahmaputra-Meghna nehirleri ise Güney Asya'daki en önemli nehir havzalarını oluşturmaktadır. İki ana koldan oluşan bu havzanın Çin'i ilgilendiren kolu Brahmaputra koludur, zira 1 milyon kilometrekareye yakın bir alanı kapsayan Ganj Nehri'nin büyük kısmı Hindistan sınırlarındadır. Brahmaputra Nehir Havzası ise Güney Çin'de önemli bir coğrafi alanı işgal etmektedir. Brahmaputra'nın Çin sınırları içinde akan 1600 kilometrelik kısmına Yarlung Zangbo adı verilmektedir. Siyasi, beşeri ve coğrafi açıdan birbirinden çok farklı olan bu bölgelerin neredeyse tamamında Çin'in su yönetimi politikaları ve bu politikalardan kaynaklı sorunlar benzer niteliktedir. Çin'in tüm bu havzalarda memba konumunda olması ve izlediği tek taraflı su yönetimi politikaları mansap ülkeler tarafından eleştirilmektedir. Esasen Çin, sınır aşan sular ile ilgili uluslararası herhangi bir yükümlülüğe girmeme gibi bir politika benimsemiştir. Özellikle 1997 Birleşmiş Milletler Su Sözleşmesi'ni imzalamaması ve bölgesel açıdan önemli su yönetimi kuruluşlarında yer almaması Çin'in bu politikasının bir yansımasıdır. Çin, sınır aşan sular konularını bazı kıyıdaş ülkeler ile imzaladığı ikili anlaşmalar ile düzenlemektedir. Çin'in dahil olmadığı bölgesel su yönetimi kuruluşları, Güneydoğu Asya'daki en önemli bölgesel işbirliği örgütleri arasında yer almaktadır. Bunlar arasında, 1995 yılında kurulmuş bulunan ve Dünya Bankası ve Asya Kalkınma Bankası gibi uluslararası kuruluşlar tarafından desteklenen Mekong Nehri Komisyonu ön plana çıkmaktadır. Diğer taraftan Çin, Asya Kalkınma Bankası teşvikiyle kurulan Büyük Mekong Alt Bölgesi Programı'na (GMS) ve ASEAN tarafından desteklenen Mekong Havzası Kalkınma İşbirliği Programı'na dahil olmuştur. Çin'in neredeyse tüm nehir havzalarını kapsayan çok sayıda hidroelektrik projesi bulunmaktadır. Çinli yetkililer bu projelerin mansap ülkelere su akışında ciddi bir sorun teşkil etmediğini vurgulasalar da, Çin'in güneydeki ülkelerle yaşadığı siyasi sorunlarla birlikte karşılıklı güven ve iş birliği eksikliği, su sorunlarının çözümünde önemli engelleri de beraberinde getirmektedir. Bunun yanında Çin, yalnızca sınırları dâhilinde değil, aynı zamanda güneyde paylaştığı sınır aşan nehir havzalarında da önemli ve büyük hidroelektrik projelerini desteklemekte veya doğrudan inşa etmektedir. Bunun en önemli sebebi, Çin'in artan iktisadi büyümesinin gerektirdiği artan enerji talebinin karşılanması gerekliliğidir. Çin, hali hazırda dünyanın en büyük hidroelektrik kurulu gücüne sahiptir ve artan enerji talebinin önemli bir kısmını hidroelektrik kaynaklardan karşılamayı hedeflemektedir. Bu bağlamda bölge dâhilindeki bazı kıyıdaş ülkeler, Çin'in yatırımlarını olumlu olarak değerlendirmekte, kısa vadede artan hidroelektrik ihracatının sağlayacağı nakit akışını gelişme potansiyelini destekleyici önemli bir girdi olarak görmektedirler. Çin'in de dahil olduğu ve 2004 yılından beri bu konuda düzenli toplantılar gerçekleştiren GMS Bölgesel Elektrik Ticareti Koordinasyon Komitesi tarafından bölgesel elektrik ticareti desteklenmektedir. Çin, bölgesel elektrik ticareti konusunu, 2010 yılından itibaren, kendi sponsorluğundaki Bir

Kuşak Bir Yol Projesi bağlamında yeniden ele almış ve bu bağlamda bölgesel bağlantıları artıracak yatırımları doğrudan destekleme kararı almıştır. Bu çerçevede Güneydoğu Asya'da artan elektrik ticaretinin getireceği kalkınma etkisinin hidropolitik ve su yönetimi sorunlarının çözümünde önemli bir rol oynayacağı düşünülebilir. Kuzey-güney farkı açısından ABD ile benzer özelliklere sahip Çin'i ABD'den ayıran bazı önemli farklar bulunmaktadır. Bunlardan en önemlisi, ABD'de yeni baraj ve hidroelektrik santral yapımı neredeyse durma noktasına gelmişken, Çin'de tersine bir durum söz konusudur. Ayrıca Çin'in güneydeki nehir havzalarında, ülke genelinde sulu tarımın etkisi, ABD'deki durumun aksine, nispeten daha azdır. Bölge genelinde, özellikle Güneydoğu ve Güney Asya'da iktisadi kalkınma, elektrik üretimi ve elektriğe ulaşım açısından ciddi farklılıklar bulunmaktadır. Bölgede elektrik ve enerji alanlarında karşılıklı iş birliği ve ticaretin artması, bu farklılıkların azalmasında önemli bir rol oynayabilir. ABD örneğinin yanında Çin örneği, hidroelektrik ticaretinin kıyıdaş ülkeler arası su sorunlarının çözümünde etkili olabileceğini göstermektedir. Bununla birlikte, iki ülkenin gerek coğrafi açıdan avantajlı pozisyonları, gerekse bulundukları nehir havzalarındaki siyasi ve ekonomik baskın konumları dolayısıyla benzerlikleri, memba konumunda olmayan ve bölgesel siyaset ve iktisat bağlamında üstünlüğü bulunmayan ülke örneklerinin de dikkate alınmasını gerektirmektedir. Bu çerçevede Kırgızistan ve Mısır örnekleri incelenmektedir.

Çalışmanın Altıncı Bölümünde incelenen Kırgızistan, Aral Gölü havzasında memba ülke konumundadır. Ceyhun nehrinin sularının dörtte üçünü Kırgızistan sınırlarında yer alan kalıcı kar ve buzullar oluşturmaktadır. Seyhun nehri ile birlikte Ceyhun nehri, Orta Asya'nın en büyük kapalı havzası olan, 1,2 milyon kilometrekarelik bir coğrafi bölgeyi içine alan Aral Gölü havzasını oluşturmaktadır. Kırgızistan'ın toplam yüzölçümünün yüzde 59'unu kapsayan Aral Gölü Havzası, Özbekistan ve Türkmenistan gibi mansap ülkelerin yüzölçümlerinin tamamına yakınını içine almaktadır. Seyhun ve Ceyhun nehirlerinin sularının önemli bir kısmı Tanrı Dağları, Pamir Dağları ve Turan Platosu'ndaki buzullar ve kalıcı karın erimesinden kaynaklanmaktadır. Bu havza genelinde, özellikle tarihi ve iktisadi gelişim açısından sulu tarıma bağımlı olan mansap ülkelerdeki tarım sektörü, suyun önemli bir kısmının tek kullanıcısı konumundadır. Sovyetler Birliği döneminde kurulan ve Orta Asya Elektrik Sistemi'ni de içeren takas mekanizmaları sayesinde, memba ülkelerde inşa edilen barajlarda kışın tutulan su, sulama mevsiminde salınarak mansap ülkelerin tarım sektörü desteklenmekteydi. Bunun karşılığında ise mansap ülkeler, memba ülkelere hidrokarbon kaynaklarının bir kısmını transfer ederek bu ülkelerin kış mevsimi için gerekli ısınma ve enerji ihtiyacını karşılamaları sağlanmaktaydı. Yazın ise su salımı sırasında üretilen ihtiyaç fazlası elektrik, Orta Asya Elektrik Sistemi'ne gönderilerek bölge ülkeleri ile paylaşılmaktaydı. Sovyetler Birliği'nin sona ermesinin ardından bölgede ortaya çıkan bağımsız devletler, bu sistemi sürdürmek üzere 1992, 1998, 1999 ve 2000 yıllarında bir dizi çok taraflı anlaşmalar imzalamış olsalar da, uzlaşmaya kapalı ve karşılıklı güvensizlik temeline oturan ilişkiler sebebiyle bu anlaşmalar kağıt üzerinde kalmış ve Orta Asya ortak elektrik ağı fiilen işlemez duruma gelmiştir. Bu yıllarda imzalanan anlaşmalar, Sovyetler Birliği dönemindeki entegre su yönetimi mekanizmalarını yeniden canlandırabilecek hukuki altyapıyı oluşturmaktadır. Bu anlaşmalar ile kurulan Milletlerarası Su Koordinasyon Komisyonu ve bu Komisyon altında faaliyet gösteren Havza Su Birlikleri bölgesel su yönetimi konusunda halihazırda önemli işlevler üstlenmektedir. Ancak, özellikle Özbekistan ve Türkmenistan'ın geniş ve kurak tarım arazilerinde yapılan sulu pamuk tarımı su kaynakları üzerinde ciddi bir baskı oluşturmaktadır. Son yıllarda pamuk üretimi ve pamuk ekilen alanlarda diğer tarım ürünleri lehine azalma görülse de bölge genelinde yürütülen sulu tarım faaliyetleri ve tarımsal üretim açısından kendine yetme siyaseti bu baskıyı artırmaktadır. Diğer taraftan, fosil kaynaklar bakımından zengin olmayan ve enerji üretimi bakımından hidroelektrik enerji üretimine ağırlık vermeyi bir politika önceliği olarak benimseyen memba ülkeler Kırgızistan ve Tacikistan, Kambarata ve Rogun gibi büyük baraj ve hidroelektrik santral projelerini tamamlayabilmenin yollarını aramaktadırlar. Siyasi ve iktisadi bakımdan baskın konumda ve her iki nehir havzası için de genel olarak mansap pozisyonunda yer alan Özbekistan ise gerek sulama suyunun azalacağı yönündeki bir endişeden, gerekse memba ülkelerin inşa edeceği barajların gerekmesi halinde siyasi bir araç olarak kullanılabilmesi ihtimalinden doğan rahatsızlıktan dolayı bu büyük projelere karşı çıkmaktadır. Memba ülkeler, bu projeleri kendi imkânları ile tamamlayabilecek maddi ve teknik kapasiteden yoksun oldukları için Rusya'nın desteği ile projeleri tamamlamak istemektedirler. Bölgede yaşanan su kaynaklı siyasi sorunlar, elektrik ticaretinin de giderek azalması ile ciddi boyutlara ulaşmıştır. Hâlihazırda eskimiş ve bakıma ihtiyacı bulunan bir sistem olsa da Orta Asya Elektrik Sistemi, bölgede elektrik ticaretinin gerçekleşebilmesi için gerekli teknik altyapıyı oluşturmaktadır. Bunun yanında, 1992 ve 1998 yıllarında imzalanan anlaşmalar elektrik ticaretinin hukuki zeminini, bu anlaşmalar çerçevesinde kurulan Orta Asya Devletler Arası Su Koordinasyon Komisyonu ve bu komisyona bağlı Havza Su Birlikleri havza yönetiminin kurumsal altyapısını teşkil etmektedir. Bu bağlamda, bölgede elektrik ticaretinin hızla ve etkili bir şekilde yeniden kurulabileceği ve artan karşılıklı bağımlılık çerçevesinde su kaynaklı sorunların iş birliği ve koordinasyon temelinde çözüme kavuşturulabileceği düşünülebilir. Diğer taraftan, özellikle Çin ve ABD gibi ülkelerin Bir Kuşak Bir Yol, CASA-1000 gibi bölgeyi ilgilendiren projeleri özelinde değerlendirildiğinde, Kırgızistan için elektrik ticaretinin yönü açısından seçenekler artmaktadır. Kırgızistan gibi kullanılmamış hidroelektrik potansiyeli yüksek bir ülke için elektrik ticareti önemli bir seçenek olarak ortaya çıkarken, potansiyelin görece düşük olduğu bir mansap ülke özelinde değerlendirme yapabilmek için Mısır örneği incelenmektedir.

Çalışmanın Yedinci Bölümünün konusunu oluşturan Mısır, neredeyse tamamen Nil nehri sularına bağımlıdır. Yeraltı suları hariç tutulduğunda Mısır'ın tek önemli su kaynağı olan Nil nehri, 6700 kilometrelik uzunluğuyla Afrika kıtasının en uzun, dünyanın ise ikinci en uzun nehridir. İklim, iktisadi faaliyet, siyasi ve beşeri yapı bakımından farklı bölgelerden geçerek Mısır'ın kuzeyinde Akdeniz'e dökülen Nil Nehri'nin 3,1 milyon kilometrekare genişliğindeki havzası içinde Mısır'ın dışında Burundi, Kongo Demokratik Cumhuriyeti, Eritre, Etiyopya, Kenya, Ruanda, Güney Sudan, Sudan, Tanzanya ve Uganda yer almaktadır. Nil'in kaynağını Ekvator Gölleri Platosu oluşturmaktadır. Bu göller arasından Victoria Gölü, Beyaz Nil olarak bilinen Nil Nehri'nin en büyük kollarından birini beslemektedir. Tana Gölü ise Mavi Nil adındaki diğer Nil kolunun temel kaynağı konumundadır. Mısır, Eritre ve Sudan'ın büyük kısmı çöllerden oluşmaktadır ve Mısır yıllık ortalama 15 milimetre gibi düşük hacimde yağmur almaktadır. Tarih boyunca en önemli uygarlık merkezlerinden biri olma özelliğini koruyan Mısır, siyasi ve iktisadi varlığını Nil nehrine borçludur. Bu bağımlılık özellikle İngiliz işgalinden sonra daha da artmış, İngiliz himayesinde Mısır, Nil nehri havzasındaki ülkeler ile anlaşmalar imzalamak suretiyle Nil sularının büyük bir bölümünün kullanım hakkını elde etmiştir. Bunlar arasında 1891 yılında İtalya ile İngiltere arasında imzalanan anlaşma, 1902 yılında İngiltere ile Etiyopya arasında imzalanan anlaşma, 1906 yılında Kongo ile Beyaz Nil suları hakkında imzalanan anlaşma sayılabilir. Ancak yakın dönemde imzalanan anlaşmalar güncel sorunların temelini teşkil etmesi bakımından daha çok önem taşımaktadır. İngiltere sömürgesi altındaki Sudan ile Mısır arasında 1929 yılında imzalanan anlaşmaya göre Mısır, Nil Nehri sularından yılda 48 kilometreküp, Sudan ise 4 kilometreküp nispetinde faydalanacaktı. Ayrıca Sudan, Nil üzerinde baraj inşa edemeyecekti. Mısırlı siyasetçiler sömürge döneminden kalma bu hakları tarihsel haklar çerçevesinde ele almışsa da sömürge devrinin sona ermesinin ardından bu anlaşmaların varlığı ve meşruiyeti tartışma konusu olmuştur. Bu nedenle 1959 yılında Mısır ve Sudan arasında Nil Sularından Tam Yararlanma Anlaşması imzalanmıştır. Bu anlaşma 1929 yılındaki su taksimini teyit etmiş, ancak Nil üzerine yapılacak barajlar ile Nil Nehri'nin su kapasitesinden mümkün olduğunca fazla yararlanılması düşünülmüştür. Bu çerçevede, bir dizi barajın yapılmasının ardından Mısır 55,5 kilometreküp, Sudan ise 18,5 kilometreküp su kullanım hakkına sahip olacaktı. Burada dikkat çeken husus, diğer kıyıdaş ülkelere su kullanım hakkının verilmemiş olmasıydı. Mısır, su ihtiyacını kalıcı olarak karşılamak amacıyla Aswan Barajı'nı Sovyetler Birliği yardımlarıyla yükseltmiş ve dünyanın en büyük baraj gölü olan Nasır Baraj Gölü'nü oluşturmuştur. Ancak zaman içinde, memba ülkelerdeki iktisadi kalkınma su ve enerji talebini beraberinde getirmiştir. Sudan, havza genelindeki en geniş sulanabilir araziye sahiptir, ancak bu arazilerin çok az bir kısmı sulanabilmektedir. Ayrıca Sudan, hidroelektrik potansiyelini kullanarak artan enerji talebini karşılamanın yollarını aramaktadır. Bunun için son dönemde büyük barajlar ve hidroelektrik santraller inşa etmiştir. Etiyopya da Sudan gibi büyük barajlar ve hidroelektrik santralleri inşa ederek iktisadi kalkınmasını desteklemek amacındadır. Bu çerçevede Etiyopya hükumeti, Arap Baharı'nın yarattığı siyaseten elverişli ortamdan da faydalanarak Büyük Etiyopya Yeniden Doğuş Barajı'nın inşasına Mısır'ın tüm muhalefetine rağmen başlamış ve bu projede sona yaklaşmıştır. Bölgede Mısır, hiçbir Nil havzası kıyıdaş ülkesi ile elektrik ticareti yapmamaktadır. Batıda Libya ve Tunus, doğuda ise Ürdün ile elektrik bağlantısı olan Mısır'ın, Doğu Afrika Elektrik Havuzu projesi çerçevesinde Sudan üzerinden Etiyopya ve Kenya'ya bağlanması gündemdedir. Bu bağlantı ve diğer planlanan elektrik iletim hatlarının inşası tamamlandığında tüm Nil nehri havzası ülkelerinin birbirlerine bağlanarak ortak bir elektrik enerjisi havuzu oluşturmaları planlanmaktadır. Bu sayede, Etiyopya ve Sudan dışında Uganda, Ruanda, Kongo Demokratik Cumhuriyeti gibi memba ülkeler de neredeyse hiç dokunulmamış olan hidroelektrik potansiyellerini kullanarak gelir elde edecek ve bölgede hızla artan enerji ihtiyacının bir kısmı hidroelektrik kaynaklardan karşılanacaktır. Bu proje uluslararası kuruluşların yanında, Nil havzasının en önemli su kuruluşu olan Nil Havzası İnisiyatifi tarafından da desteklenmektedir.

Bu çalışma ile dünyanın en yoğun sınır aşan elektrik enerjisi ticaretinin gerçekleştiği Kuzey Amerika'dan Nil nehri kıyıdaş ülkeleri ile fiziki hiçbir bağlantısı bulunmayan Mısır'a kadar dünyanın farklı coğrafyalarında su yönetimi ile elektrik ticaretini temel alan modeller incelenmiştir. Ulusal kalkınmanın tarih boyunca en temel taşlarından olan hidroelektrik üretimi, özellikle yirminci yüzyılın ikinci yarısından itibaren tartışmalı hale gelmiştir. Bazı bölgelerde siyasi tarihin rolü ve bölgesel güç çatışmaları sınır aşan sular bağlamında önemli etkenler olmaktayken, çoğu zaman sınır aşan sular meseleleri iktisadi sahada tezahür etmektedir. Hükümetler ve uluslararası kuruluşlar çoğu zaman tartışmalı olan büyük baraj projelerine iktisadi kalkınma meşru zemininde destek vermektedirler.

Bu çalışma kapsamında ele alınan ülkelerden bazılarının toplam yüzölçümlerinin yarısından fazlası tek bir nehir havzasında yer almaktadır. Bunlar arasında Tacikistan, Uganda, Laos, Kamboçya, Özbekistan, Ruanda, Sudan ve Kırgızistan gibi ülkeler bulunmaktadır. Bu ülkeler için havza su kaynaklarına yönelik riskler, ciddi problemler oluşturabilmektedir. Ancak daha anlamlı bir analiz yapmak için havza ülkelerinin havza su kaynaklarına bağımlılığı değerlendirilmelidir. Örneğin Kırgızistan'ın yüzölçümünün yüzde 60'a yakını Aral Havzası'nda bulunmaktadır, ancak su kaynaklarına ekonomik bağımlılığı yüzde 30 mertebesindedir. Mısır ise Nil Havzası dahilinde topraklarının yüzde 21'i bulunmasına rağmen, Nil sularına iktisadi bağımlılığı yüzde 80'in üzerindedir. Bu iktisadi bağımlılık seviyesi, ülkeler arasındaki hidropolitik ilişkilere doğrudan etki ettiği gibi, aynı zamanda başlıca uluslararası kuruluşların da dikkatini belli başlı havzalara çekmektedir. İktisadi kalkınma bağlamında birçok uluslararası kuruluş, çevresel açıdan tartışmalı büyük baraj projelerini desteklemiş ve ülkeler arasındaki su kaynaklı iktisadi sorun alanlarına doğrudan müdahil olmuştur.

Büyük baraj projeleri ile birlikte yürüyen ve devletlerin bürokratik mekanizmalarının sponsorluğunda yaygınlaşan büyük sulama projeleri, sorun alanlarının en önemlilerinden birine temel teşkil etmektedir. Genel olarak bakıldığında, bu büyük projelerin dünya çapında neredeyse aynı dönemde yaygınlaştığı ve hız kazandığı gözlemlenmektedir. Imperial ve Fergana Vadisi'ndeki sulama sistemlerinin paralel gelişimleri buna bir örnektir. Zaman ilerledikçe, hidroelektrik üretiminin de bu sisteme artan bir hızla dahil olması, sorun alanlarını daha karmaşık hale getirmiştir.

Dünya genelinde, özellikle gelişmekte olan ülkelerde, tarım sektörü su talebinin büyük bir kısmını oluşturmaktadır. ABD gibi gelişmiş ülkeler de su tüketiminin yoğun olduğu ülkeler olmakla birlikte, bu ülkelerde sanayi kaynaklı su tüketiminin de büyük payı vardır. Ancak gelişmiş ülkelerde, toplam su tüketiminin genel olarak azalma eğiliminde olduğu gözlemlenmektedir. Bununla birlikte, yağış ve iklim bağlamında belli ülkeler, su kaynaklarının büyük çoğunluğunu kullanmış durumdadırlar. Bunlar arasında bu çalışmada incelenen Özbekistan, Türkmenistan, Mısır ve Sudan dikkat çekmektedir. Bu ülkelerde yapılan sulu tarımın yoğunluğunun azaltılarak sanal su ticaretinin artırılması önemli bir politika tercihi olarak ön plana çıkmaktadır.

Bir ülkede inşa edilen büyük bir baraj, nehir havzası içinde yer alan diğer ülkeler açısından endişe kaynağı olabilmekte, ülkeler arasında iktisadi temelli sorun alanlarının artmasına veya yenilerinin oluşmasına temel teşkil edebilmektedir. Genelde memba ülkelerde suyun büyük barajlar tarafından alıkonulması ve bu sular ile hidroelektrik enerji üretilmek istenmesi durumlarında ülkeler arası sorunlar artmaktadır. Bunun örnekleri Mezopotamya, Aral ve Nil havzalarında gözlemlenmektedir. Bu gibi durumlarda uluslararası anlaşmalar ve rejimler yeterli olmayabilir. Bu çerçevede, bölgesel hidroelektrik üretimi ve üretilen hidroelektrik gücün kıyıdaş ülkeler arasında paylaşılması ve ticareti ön plana çıkmaktadır. Nehir havzalarında iktisadi temelli sorun alanlarının çözümünde bölgesel elektrik ticaretinin rolünü, bu çalışmada incelenen modeller ortaya koymaktadır.

Kuzey Amerika'da yüksek hacimlerde gerçekleşen elektrik ticareti ile birlikte sağlam ticari bağlar, ikili su sorunlarının çözümünde önemli rol oynamaktadır, ancak bu bölgede iklim, yağış miktarı, hidroelektrik potansiyeli gibi unsurlar da sorunların şeklini ve şiddetini etkileyebilmektedir. Nitekim elektrik ticaretinin daha düşük seviyede seyrettiği Meksika – ABD sınırında su kıtlığı çerçevesinde yaşanan iktisadi temelli sorunların boyutu daha yüksektir. Bu çerçevede, ABD ile karşılaştırılabilecek boyutta bir ekonomisi ve hidroelektrik gelişmişliği olan Çin'de de benzer bir durum olduğu göze çarpmaktadır. Çin'in elektrik ticaretine yönelik bölgesel yatırımlarının özellikle Çin'in güneyindeki nehir havzalarında yaşanan iktisadi temelli problemlerini azaltacağı öngörülebilir. Çin ve ABD mertebesinde bölgesinde iktisadi açıdan baskın olmayan ülkeler için de benzer bir durum söz konusudur. Kırgızistan örneğinde görüleceği üzere, Sovyetler Birliği döneminde inşa edilen Orta Asya Güç Sistemi'nin işlemez duruma gelmesi, bölgedeki ekonomi temelli su problemlerini artırmaktadır. Bu nedenle bölge ülkeleri, Çin ve ABD gibi ülkelerin ekonomik destekleri ile bölgede elektrik üretimini ve ticaretini artırıcı yollar aramaktadırlar. Benzer bir durum, Mısır'da söz konusudur. Mısır'ın Nil Nehri havzası kıyıdaş ülkeleri ile elektrik ticareti bağının olmaması, bölgede yaşanan su temelli gerilimleri ve güç mücadelesini artırmıştır. Son dönemde uluslararası kuruluşların da desteğiyle artırılmak istenen elektrik ticareti ve entegrasyonunun bu sorunların kalıcı çözümünde önemli bir kilometre taşı olacağı değerlendirilmektedir.

Bu çalışmada incelenen modellerin karşılaştırmalı analizi göstermektedir ki sınır aşan önemli nehir havzalarında yaşanan iktisat temelli problemlerin yoğunluğu ile elektrik ticareti arasında ters yönlü bir ilişki bulunmaktadır. Bu durum yalnızca gelişmekte olan ülkeler için değil, ABD gibi gelişmiş ülkeler için de geçerlidir. Birçok bölgede elektrik bağlantı projeleri güncellenmekte ve yeni bağlantı hatları inşa edilmektedir. Ancak su sorununun iktisadi entegrasyon temelli kalıcı bir çözümü için elektrik bağlantı projeleri ile nehir havzası yönetimi yaklaşımlarının bir arada değerlendirilmeleri önem arz etmektedir.

Appendix B: Vita

CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name: Sakal, Halil Burak
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EDUCATION

Degree	Institution	Year of Graduation
MA	Bilkent University, International Relations	2010
Undergraduate	Ankara University, Business Administration	2007
High School	Ankara Anadolu High School, Ankara	2003

WORK EXPERIENCE

Year	Place	Enrollment
2009-2018	Türkiye Cumhuriyet Merkez Bankası	Central Bank Specialist
2007-2009	Bilkent University, Department of IR	Research Assistant

FOREIGN LANGUAGES

Advanced English, Fluent German

PUBLICATIONS

Theses

Halil Burak Sakal: *Türkiye ekonomisinin genel görünümü ile Türkiye Cumhuriyet Merkez Bankası Para Politikası Kurulu faiz kararları erişim sayıları arasındaki ilişkinin incelenmesi*. 11/2014, Degree: Professional, Supervisor: Ümit Özlale, DOI:10.13140/2.1.2982.4804.

Halil Burak Sakal: *Germany and Turkestanis during the Course of the World War II (1941-1945)*. 07/2010, Degree: Master of Arts in International Relations, Supervisor: Hasan Ali Karasar.

Books

Halil Burak Sakal, Oktay Tanrısever: *Development of Hydropower Sector and Its Impact on Energy-Environment Nexus in Central Asia*. 11/2017; Eurasian Research Institute (ERI)., ISBN: 978-601-7805-11-1.

Halil Burak Sakal: *Başka Bir Dünya Savaşı: İkinci Dünya Savaşı Sırasında Almanya Tarafında Savaşan Türkistanlılar (1941-1945)*. 1 08/2013; Ötüken Neşriyat., ISBN: 978-975-437-981-5, DOI:10.13140/2.1.4207.4569.

Book Chapters

Oktay Tanrısever, Halil Burak Sakal: Transboundary Water Management Policies of the Riparian States of the Kura-Araks River Basin in the Post-Soviet Period. *Sustainable Water Use and Management*, 1 edited by Walter Leal Filho, Vakur Sümer, 2018 (in press); Springer Switzerland.

Halil Burak Sakal, Oktay Tanrısever: Declining Global Energy Prices and Challenges for the Sustainability of Azerbaijan's Economic Development and Energy Policy, *Study Series on Public Policy Issues*, Baku, 2018 (in press).

Halil Burak Sakal: Think-Tanks and Economic Decision-Making in Turkey. *Think-Tanks in Eurasia*, 1 edited by Hasan Ali Karasar, Hasan Kanbolat, 06/2013: pages 167-182; Nobel Academic Publishing., ISBN: 9786051334547.

Journal Publications

Halil Burak Sakal: A Quarter-Century Pursuit of Independence: Politics of Trade, Energy, and Economic Development in Uzbekistan. *Perceptions* 2017; 22(1).

Halil Burak Sakal: Hydroelectricity Aspect of the Uzbek – Kyrgyz Water Dispute in the Syr Darya Basin. *Energy and Diplomacy* 2015; 1(3).

Halil Burak Sakal: Natural resource policies and standard of living in Kazakhstan. *Central Asian Survey* 12/2014; 34(2)., DOI:10.1080/02634937.2014.987970.

Conference Proceedings

Halil Burak Sakal: "Socialist Rivers" and the Environmental History of Central Asia during the Cold War. *The Social History and Anthropogenic Landscape of the Syr Darya River Basin: Exploring an Environmental Archive*, Tashkent; 04/2016, DOI:10.13140/RG.2.2.18644.19841.

Appendix C

TEZ FOTOKOPİSİ İZİN FORMU

ENSTİTÜ

Fen Bilimleri Enstitüsü	☐
Sosyal Bilimler Enstitüsü	☒
Uygulamalı Matematik Enstitüsü	☐
Enformatik Enstitüsü	☐
Deniz Bilimleri Enstitüsü	☐

YAZARIN

Soyadı : Sakal
Adı : Halil Burak
Bölümü : Uluslararası İlişkiler

TEZİN ADI (İngilizce): Models of Regulating Water in Transboundary River Basins: A Nexus of Hydropolitics and Electricity Trade

TEZİN TÜRÜ : Yüksek Lisans ☐ Doktora ☒

1. Tezimin tamamından kaynak gösterilmek şartıyla fotokopi alınabilir. ☒
2. Tezimin içindekiler sayfası, özet, indeks sayfalarından ve/veya bir bölümünden kaynak gösterilmek şartıyla fotokopi alınabilir. ☐
3. Tezimden bir bir (1) yıl süreyle fotokopi alınamaz. ☐

TEZİN KÜTÜPHANEYE TESLİM TARİHİ: