Making Benefit-Sharing a Success

Multi-Level Institutional Analysis of Benefit-Sharing in Managing Shared Water Resources, a Case from Central Asia

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Making Benefit-Sharing a Success. Multi-Level Institutional Analysis of Benefit-Sharing in Managing Shared Water Resources, a Case from Central Asia

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It is to my parents, born and raised near the Aral Sea, this thesis is dedicated:

To my late father, Dr. Babakayev Saliy Napesovich,
who from being a shepherd as a kid in a remote village of Karakalpakstan grew to become
an Associate Professor at Tashkent Institute of Architecture and Construction
where he taught Higher Mathematics and led research in Numerical Methods
He was fluent in six languages and had a humble yet a very bright and joyous character
My best friend, science- and life- inspirer
May he rest in eternal peace

To my mother, Shamuratova Khaytbeka,
who fought her way to studies and became a teacher,
she taught mathematics for more than 40 years
in schools and lyceums of Karakalpakstan and Tashkent,
and has been selflessly supporting everyone in the family in achieving our goals
She influenced me greatly with her moral values, most of all honesty and hard work,
and encouraged to pursue my interests and always move only forward
even when it meant that I would be far from her
May she be strong and live long

Preface

As in the well-known saying, referred by some as the Socratic paradox, it has indeed been such a paradoxical phenomenon that learning, in fact the most intensive learning I have experienced by far, has made me know how little, if anything, I know.

I commenced this doctoral research with the idea that I would learn exactly how to solve some critical life challenges, at least how to make a contribution to solving some part of a challenge. For me, the critical life challenge to solution of which I want to contribute has been related to the story of the Aral Sea. No matter how well you know the story and say that given the circumstances there is hardly anything to be surprised about, it is still astonishing what human made to the once flourishing and the fourth largest lake of the world in a matter of just 40-50 years. My bit as I thought was to develop benefit sharing options to facilitate cooperation among countries sharing the Aral Sea basin. Very soon I realized how advanced the relationship among these countries already was and how ignoring it would be from me to develop a simplistic model without taking into account as much of available knowledge as possible. I realized that almost the entire history of water development in the region could be seen as benefit sharing. Then the question became what we could learn from the past and existing benefit sharing before suggesting another layer of enthusiastic options on top. What can we learn about reasons that led to unwanted results, how could they be prevented and what are the key drivers determining various outcomes, not only those promising quick short-term benefits but also those defining long-term fundamental transformations? This thesis I hope clarifies these questions at least to some degree.

I am greatly indebted to my advisor Prof. Dr. Volkmar Hartje, Head at the Chair of Landscape Economics of Technical University of Berlin, who saw me as a trustworthy candidate when we first communicated via email in 2011. Discussions with him were instrumental both in understanding how I could put together my motivation, knowledge and experience into a feasible research proposal at the initial stage, and in re-thinking and adjusting my approach as I was progressing and discovering a great deal of nuances. Prof. Hartje has a vast experience in applying economic instruments to natural resources management, it has been a privilege to learn from him and I am grateful for his wisdom, solution-oriented attitude, patience and support whenever I approached him for advice.

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Contacting and later meeting Dr. Kai Wegerich, whom a recent study with meta-analysis found as the most published and cited scholar in the field of water resources

management in Central Asia, indeed was one of the most decisive points for this research. In 2013 Dr. Wegerich introduced me to the Ferghana Valley and to the research at the International Water Management Institute (IWMI) being conducted and accumulated at the time. Ever since I have been privileged to work with Dr. Wegerich, to enjoy his exceptional support, to learn from his extensive experience and stimulating discussions we had throughout these years. I am also thankful to Dr. Jusipbek Kazbekov whom I was fortunate to meet during my internship at the IWMI. Dr. Kazbekov is a rare expert who knows both sides: peculiarities from within the region as he was born, grew up there and studied water resources of the region for the most part of his career, and global perspectives as he has a well recognized and long experience in international research. Dr. Kazbekov has been one of the most understanding and supportive persons during these years. Furthermore, I thank the entire IWMI Central Asia team (in alphabetical order): Indira Akramova, Oyture Anarbekov, Ilhom Babaev, Davron Eshmuratov, Zafar Gafurov, Kahramon Jumaboyev, Firdavs Kabilov, Dr. Akmal Karimov, Nozilakhon Mukhamedova, Dr. Mariya Pak, Alexander Platonov, Ilshat Tukhvatullin and Murat Yakubov, all of whom have welcomed me as a friend during my stays in Tashkent.

I am very thankful to Prof. Dr. Insa Theesfeld, Head at the Chair of Agricultural, Environmental and Food Policy of Martin-Luther University Halle-Wittenberg, who kindly agreed to serve as the second advisor of my research. Prof. Theesfeld is one of the leading scholars in institutional economics and commons research, visiting scholar of Ostrom's workshop, council member of the International Association for the Study of the Commons. I have been learning a lot from how Prof. Theesfeld can find ways to frame key points so clearly even when things appear too complex. Prof. Theesfeld's feedback on a number of aspects of my research has greatly helped me to develop my ideas further. She is also one of the most thoughtful persons I have met in the way how much care she puts into collaboration with her colleagues and students.

I was also very fortunate to have met Prof. Dr. Christian von Hirschhausen and Markus Siehlow, and their team at the Workgroup for Infrastructure Policy at Technical University of Berlin. They have one of the most dynamic teams I have seen by far with an impressive portfolio of research projects running on levels of cutting-edge sophistication. They have showed nothing but support and interest in collaboration since I joined their modeling project in 2012.

I would like to thank Prof. Dr. Rashid Kulmatov of National University of Uzbekistan. I met him during my studies in Budapest where he presented his research on various perspectives of managing water resources in the Aral Sea basin. He has always supported me ever since encouraging to continue pursuing my interest in the subject and sharing his knowledge and wisdom.

I thank Dr. Nodir Djanibekov, whom I met at a Conference he organized in Halle in 2014. Dr. Djanibekov is one of the most hard working researchers I have met, he is very talented in communicating his ideas, too, and is rightly one of the central figures in research related to agricultural water and land economics in Central Asia. I appreciate his personal support and I am grateful for his interest in my research and continuously encouraging me to present my findings to a wider audience.

I am grateful to the German Academic Exchange Service (DAAD) for their funding support and giving me the luxury of time to work on this subject for four years. Along the way, my work benefited from discussions with experts and policy makers at a number of international conferences and workshops. I would like to acknowledge also the funding support which made my participation in these events possible. I thank (in chronological order) Stockholm International Water Institute (SIWI) for selecting my work for presentation at the World Water Week 2013 in Stockholm and supporting my participation, Leibniz Institute of Agricultural Development in Transition Economies (IAMO) for selecting my work for presentation at the 2014 Conference in Halle and supporting my participation, the International Association for the Study of the Commons for selecting my work for presentation at the 15th Biannual Global Conference of the Commons in Edmonton, Alberta in 2015 and Friends of TU for supporting my participation, the Summer University at Central European University for selecting my work for presentation at the 2015 Workshop on ICTs and Water Security in Budapest and supporting my participation, IAMO for selecting my work for presentation at the 2016 Inter-Conference Symposium in Almaty, and the Local Organizing Committee of the 7th International Conference on Water Resources and Environment Research (ICWRER) for selecting my work for presentation at the ICWRER2016 in Kyoto and supporting my participation. Special thanks to the ICWRER's Awards Committee who selected me and my contribution for the Takasao Memorial Prize.

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With sincere appreciation,
Ilkhom Soliev

Summary

In the light of growing global water crises, benefit sharing has been increasingly suggested to transform a potential conflict over transboundary water resources into an opportunity to enhance cooperation and therefore turn the zero-sum game into a positive sum.

This thesis argues that a rigorous and multi-level institutional analysis is needed for making benefit sharing a success. First, the thesis analyzes the long-term dynamics of transboundary institutions governing water and land in the Ferghana Valley, Central Asia. The specific attention is paid to the sources leading to establishment and shifts in institutions on different levels and implications for the ways costs and benefits from transboundary projects are shared as a result. Second, it is argued that four groups of identified indirect costs as well as direct operational and maintenance costs need to be better integrated into benefit sharing arrangements for these new arrangements to be sustainable in the long run. The four groups of indirect costs of benefit sharing include: costs related to equity of sharing as well as toward affected population, costs to the environment, increased transaction costs due to complexity of issue linkages, as well as costs as a result of possible misuse of asymmetric issue linkages. Finally, key sources of path dependency are examined to understand the degree of change in reallocation under various socio-economic, techno-environmental and institutional conditions. It is identified that interplay among vested interests, infrastructure control and network effects will determine how far the economic rationale of benefit sharing, which envisages reallocation of water resources to more beneficial uses, can be satisfied.

A large collection of data representing interaction and decisions among riparians in the Ferghana Valley on international, national and sub-national levels such as agreements, protocols and correspondence is analyzed for the last 100 years. In addition, budget reports of the Ferghana province water management department from 1978 to 2010 are analyzed to identify operational and maintenance costs related to transboundary benefit sharing arrangements in a systematic way. Evidence is presented on institutional arrangements to property rights, sharing criteria, governance structures and allocative efficiency to identify (1) how institutions affecting water and land development projects with shared benefits evolved over the last century and (2) how institutional and infrastructure linkages established earlier affect cooperative solutions proposed at present.

The research demonstrated that benefit sharing indeed helped to facilitate negotiation and achieve win-win solutions. However, focusing on short-term opportunities made future negotiations less effective. Unaccounted path dependency and accumulated tension in risk categories burst during later negotiations leading to disagreements on various degrees. Hence, should reforms aimed at achieving water security and facilitating transboundary cooperation pursue solutions stable in the long-run and use benefit sharing as an approach, its risks and costs must be taken into account. Finally, the findings of the thesis stress that in an environment of high institutional complexity making benefit sharing a success requires a correspondingly high level of personnel and technical capacity of involved actors to understand and cope with complex challenges.

Zusammenfassung

Im Lichte der wachsenden globalen Wasserkrise wird Benefit Sharing zunehmend als eine Möglichkeit angesehen, potenzielle grenzüberschreitende Konflikte um Wasserressourcen in Kooperationen zu transformieren und somit aus einem Null-Summen-Spiel ein Positiv-Summen-Spiel zu machen.

Die vorliegende Dissertation zeigt, dass eine strikte Mehr-Ebenen-Institutionenanalyse nötig ist, um ein erfolgreiches Benefit Sharing zu gewährleisten. In einem ersten Schritt wird die langfristige Entwicklungsdynamik grenzüberschreitender Institutionen analysiert, welche die Land- und Wassernutzung im Ferghana Tal, Zentralasien regeln. Besondere Aufmerksamkeit wird hierbei denjenigen Ursachen gewidmet, die zur Etablierung und Veränderung von Institutionen auf verschiedenen Ebenen beigetragen haben. Zudem werden die hieraus resultierenden Konsequenzen für die Aufteilung grenzüberschreitender Kosten und Nutzen analysiert. Im nächsten Schritt wird herausgestellt, dass es für einen nachhaltigen Erfolg des Benefit Sharings notwendig ist, die indirekten Kosten sowie direkte Betriebs- und Wartungskosten in Benefit Sharing-Abkommen zu integrieren. Die vier Arten indirekter Kosten beinhalten Kosten einer gerechten Aufteilung auf lokaler und zwischenstaatlicher Ebene, Umweltkosten, gestiegene Transaktionskosten aufgrund komplexer Paketlösungen (issue linkages) sowie Kosten, welche durch einen möglichen Missbrauch von asymmetrischer Paketlösungen hervorgerufen werden. Abschließend werden wichtige Ursachen einer Pfadabhängigkeit untersucht, um der Veränderungsgrad einer Umverteilung unter verschiedenen sozi-ökonomischen, umwelttechnischen und institutionellen Bedingungen zu erfassen. Hierbei stellt sich heraus, dass das Zusammenspiel von Eigeninteressen, Infrastruktursteuerung und Netzwerkeffekten determiniert, inwieweit das ökonomische Rational des Benefit Sharings, welches eine vorteilhafte Umverteilung von Wasserressourcen vorsieht, erreicht werden kann.

Im Rahmen der Arbeit wurde eine umfangreiche Sammlung von Daten wie Übereinkommen, Protokolle, Korrespondenzen, etc. hinsichtlich von Interaktionen und Entscheidungen zwischen Anrainerstaaten des Ferghana Tals untersucht. Berücksichtigt wurden hierbei Dokumente der letzten einhundert Jahre auf regionaler, nationaler und internationaler Ebene. Des weiteren wurden Budgetberichte der Wassermanagement-Abteilung der Ferghana-Provinz der Jahre 1978 bis 2010 untersucht, um Betriebs- und Wartungskosten bezüglich grenzüberschreitender Benefit Sharing-Abkommen systematisch zu identifizieren. Es wird Evidenz zu institutionellen Vereinbarungen über Eigentumsrechte, Sharing-Kriterien, Governance-Strukturen und Allokationseffizienz präsentiert, um zu zeigen (1) wie Institutionen, welche Wasser- und Landeentwicklungsprojekte mit geteiltem Nutzen beeinflussen, sich über die letzten Jahrhundert herausgebildet haben, und (2) wie institutionelle und infrastrukturelle Verbindungen, die zu einem früheren Zeitpunkt etabliert wurden, gegenwärtig vorgeschlagene kooperative Lösungsansätze beeinflussen.

Diese Dissertation zeigt, dass Benefit Sharing in der Tat geholfen hat Verhandlungen zu ermöglichen und zu Win-Win-Lösungen zu führen. Hierbei zeigt sich jedoch auch, das ein Fokus auf kurzfristigen Nutzen die Effektivität anschießender Verhandlungen vermindert hat. Unberücksichtigte Pfadabhängigkeiten und über die Zeit aufgestaute

Spannungen in verschiedenen Risikokategorien führen zu Meinungsverschiedenheiten auf verschiedenen Ebenen. Hieraus ergibt sich, dass Risiken und Kosten des Benefit Sharings bei zukünftigen Reformen, die darauf abzielen, langfristig stabile Wassersicherheit herzustellen und Lösungen grenzüberschreitender Kooperationen zu ermöglichen, berücksichtigt werden sollten. Abschließend betont diese Forschungsarbeit, dass es im Umfeld einer hohen institutionellen Komplexität für das Gelingen des Benefit Sharings eines hohen Maßen an technischer und personeller Ausstattung bedarf, um die komplexen Herausforderungen zu verstehen und zu bewältigen.

Contents

1 Introduction

The thesis investigates the question of to what extent benefit sharing approach is applicable to address *the need for* and *implications of* riparian water reallocation. This is done through a multi-level institutional analysis of changing from a status quo to a new allocation among riparians and the consequences thereof. A case of transboundary water resources from Central Asia, regarded as one of the most complicated humanly devised water management systems in the world (Raskin et al. 1992), is tested to understand conditions for successful benefit sharing.

The remainder of this Chapter is structured as follows. First, the scene is set to shed light on the intensifying need for riparian reallocations in the context of growing global water crises. Then the benefit sharing approach is introduced as a potential solution to the questions of riparian water reallocation. This is followed by introduction of the case study area. The subsequent section describes the methodological-analytical approach and what is meant by multi-level institutional analysis. The final section explains the objectives of the thesis by setting specific research questions as well as their division across the thesis.

1.1 The need for riparian water reallocation

From 2011 to 2015 the Annual Global Risks Reports of the World Economic Forum identified water crises as one of the top global risks of our time while the Report in 2015 evaluated the potential crises as the risk with the highest impact. Transboundary water resources – the focus of this research – constitute a significant share of global water supply. There are 276 international river basins shared by two or more countries covering almost half of the global surface. A total of 148 States include territory within such basins. About 40% of the world population lives in transboundary basins and over 90% in a country that shares a transboundary river basin (UN Water 2013).

Even under most optimistic scenarios, projections are such that dynamics in population growth, development needs, and climate effects are to contribute to dramatic increases in water scarcity in many parts of the globe, particularly in Africa, Asia and Latin America already within a few decades (e.g. Alcamo et al. 2007; Davis et al. 2016). The concerns have grown to an extent that achieving and maintaining water security is viewed as detrimental to economic growth (Sadoff et al. 2015). In 2010 research published in *Nature* (Vorosmarty et al. 2010: 555) warned that "nearly 80% of world's population is exposed to high levels of threat to water security" and a more recent study (Munia et al. 2016) found that high water stress was already affecting at least 33%-51% of population in transboundary river basins.

Reallocation of available freshwater resources comes forward almost universally as one of the central prerequisites both for moving from water crisis to water security and maintaining the existing water security in the face of changing circumstances (Ohlsson and Turton 1999; Molle 2003). Naturally, when it comes to transboundary river basins national response to water scarcity in one state might affect water uses in another and lead to disagreements on various intensities as a result. More specific sources of such disagreements may vary; the most commonly identified case is when upstream uses are in conflict with downstream uses. The potential to solve such disagreements is often affected by the nature of existing relations among riparian states. Trust in relations, power constellation, riparian position and exploitation potential, physical and institutional interdependencies are among those factors that can create both incentives and disincentives to find and implement solutions. Differences in perceptions and interpretations as to what is an "equitable and reasonable" sharing and what constitutes a "significant harm", if principles of international water law are to follow, are also hardly helpful for moving towards solutions (Wegerich and Olsson 2010; Eckstein 2014a, 2014b). At the same time, relations over transboundary water resources might have spillover effects in other areas of international relations. With growing pressure to utilize more on the one hand and available supplies approaching their limits on the other hand, competition and disputes over transboundary resources are likely to increase.

Against this background, the underlying debate can be grouped into two fundamental questions: (i) how to facilitate cooperative actions when there are disagreements? and (ii) how to maintain cooperative relations? The aim of this thesis is to investigate how benefit sharing, introduced in the next section, can address these two questions as an approach based on an economic reasoning. Taking the approach which is based on an economic reasoning, institutional and legal conditions affecting benefit sharing as well as benefits from cooperation are examined by identifying the sources of incentives and constraints on international, national and sub-national levels while taking into account specifics of water use in different techno-environmental conditions. The thesis, therefore, can be viewed as an interdisciplinary research at the interface of hydrology, law and economics.

Adapting from multiple sources, the following broad definitions are applied within this thesis while more specific definitions are presented when addressing corresponding specific aspects of the research. International or transboundary waters are freshwater resources shared mostly across sovereign states and to some extent those crossing administrative boundaries of states with sufficiently strong autonomy in decision making. Hence, water resources crossing federal state boundaries might be also considered as transboundary as long as authority in decision making largely rests with these states. While conflict is understood as an interaction through which the status quo allocation of the resource is contested, cooperation is viewed as an interaction aimed at increasing gains from joint efforts. Finally, institutions are rules in use shaping the incentives and constraints in interactions among riparian states, including those which constitute organizations.

1.2 Benefit sharing: transforming the main question

The discourse on conflict and cooperation over transboundary water resources has evolved significantly over the last three decades. Predictions in the early 1990s warned about water becoming a source of wars in the 21st century (e.g. Starr 1991; Gleick 1993; Homer-Dixon 1994). This was followed by empirical studies which by the late 1990s showed that historically cooperation over transboundary waters had been far more common than conflict (Wolf 1998). In the 2000s there has been growth in the literature with optimistic and solution oriented views aimed at transforming cases with conflicting interests over transboundary waters into an opportunity to foster cooperation (e.g. Sadoff and Grey 2002, 2005; Phillips et al. 2006; Qaddumi 2008). Finally, a significant contribution has been made by scholars reiterating the complexity of the transboundary water management and highlighting co-existence of conflict and cooperation (Zeitoun and Warner 2006; Zeitoun and Mirumachi 2008; Zeitoun et al. 2011; Zeitoun et al. 2016). Although the focus might have differed within the above approaches, there is a universal recognition of the necessity to enhance and maintain cooperative actions over transboundary water resources.

The solution oriented views of the 2000s resulted in re-invention of the benefit sharing approach promoting its application in transboundary water management. The idea of the approach replicates what had been known as “mutual gains” approach in the negotiation research since 1980s (Fisher and Ury 1981) (Fig. 1). Sewell and Utton (1986: 201) contrasted mutually gainful cooperation with “a great deal to lose from intransigence” on the examples of United States – Canadian water disputes (Krutilla 1967). They stated that focusing on rights prevented from mutually beneficial cooperation and that “some major changes in attitude, accompanied by modifications in institutions” were needed for cooperation to be facilitated.

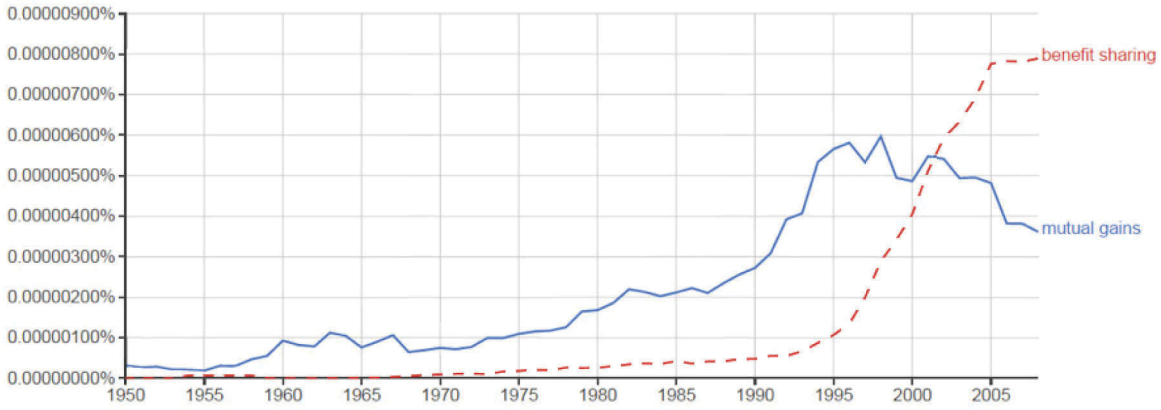

Fig. 1.1. Google Ngram trend analysis of phrase appearance in books 1950-2008

The idea of benefit sharing is to focus on potential benefits in negotiations over shared waters rather than on limited quantities of water (e.g. Sadoff and Grey 2002). While focusing on water quantity results in a zero-sum game, where one's gain is another's loss, focusing on benefits opens up a wide range of additional options where win-win becomes possible. The origins of the positive sum could be traced back to game theoretical concepts such as Pareto improvement when utility is improved at least for one user without harming any other users in an interaction with a set of users. Assuming status quo allocation is contested or reallocation is needed for coping with water stress in general, the benefit sharing approach transforms the main question of reallocation from "who gets what" to "how to improve it for all" and therefore circumvent the very conflict of the main reallocation question (Table 1).

Table 1.1. How benefit sharing approach transforms the main question of allocation

Approaches	**Water rights**	**Benefit sharing**
Focus	On water quantities	On benefits from water use and allocation
Main question	What should be the shares?	What could increase total net benefits?
Debate focus	Why certain shares? • According to existing agreements • Following principles of international water law • Due to the needs, opportunities, ambitions, etc.	What are the options? • New infrastructure • Rearranging agreements • Issue linkages: - with other sectors (energy, food, transport, etc.) - with other basins
Likely outcome	Disagreements	Agreements

Historically, the approach has helped to find mutually beneficial solutions among riparians in a number of shared water basins around the world. With the 1961 Columbia River Treaty (used as a successful example by many authors including Sewell and Utton 1986), the US succeeded to negotiate changes in Canada's hydropower projects, where

US would benefit from flood control while Canada would receive payments and additional rights for diversions between the Columbia and Kootenai for hydropower (Giordano and Wolf 2003). On the Senegal river, Senegal, Mali and Mauritania agreed to share the development costs and benefits of joint infrastructure using a burden-sharing formula (Hensengerth et al. 2012). The Lesotho Highlands Project on the Orange-Senqu river basin involves direct payments for water, purchase agreements and financing arrangements. Through cooperation on the Aswan High Dam on the Nile, Egypt and Sudan succeeded to increase the water allocated to both countries. On the Zambezi, ownership, costs and benefits of the Kariba dam are equally shared between Zambia and Zimbabwe. India's agreement with Nepal on the Mahakali river includes cost sharing and a power purchase arrangement; India-Bhutan agreement on the Chukha hydropower project includes payments made by India to Bhutan for power exports (Klaphake 2006). Some non-dam centered examples include cases when riparians achieved cooperation by making mutual concessions on several shared rivers (US and Mexico; South Africa, Swaziland and Mozambique) or while connecting water-related issues with issues outside the water sector (Klaphake 2006; Phillips et al. 2008).

1.2.1 Potential advantages of benefit sharing

Three important factors make benefit sharing powerful and attractive: the idea, the scope and the forms of benefit sharing.

Benefit sharing enlarges the cake itself. As explained, the idea is to focus on broad range of benefits from cooperation rather than on a limited quantity of water. Assuming symbolically that water resources at any given time are "a shared cake" among the users, the idea of the former is to allow enlarging the "cake" itself by re-arranging existing or bringing in additional ingredients while the latter would focus on increasing the individual shares inevitably leading to a zero-sum game. The definition of benefit sharing, "any action designed to change the allocation of costs and benefits associated with cooperation*"* (Sadoff and Grey 2005: p.3)*,* practically embodies the answer to why positive sum is possible. The term "any action" is very broad and completely shifts the focus to action and cooperation (Klaphake 2006; Dombrowsky 2007; Turton 2008; Qaddumi 2008; Phillips et al. 2006, 2008; Phillips 2009; Hensengerth et al. 2012).

Benefit sharing encourages thinking outside the box. The scope of "benefits" is also broad, which in turn enables riparians to cooperate on the widest range of subjects. Contrary to a more conventional perception of benefits in pure economic terms, typology of benefit sharing (Sadoff and Grey 2002, 2005) widens this perspective and covers the entire spectrum of benefits: environmental (benefits to the river) – Type 1, economic (benefits from the river) – Type 2, political (costs reduced because of the river) – Type 3 and catalytic (benefits beyond the river) – Type 4.

Benefit sharing helps get things done collectively when they cannot be done alone. There are clear mechanisms for developing concrete practical solutions, and the ways in which benefit sharing can be arranged are plenty. Overall, they can be grouped into (1) compensations – financial and in kind, and (2) issue linkages – where agreements are reached by linking several issues, for example, connecting trade-offs on different rivers or water sector with such sectors as energy, food, transport, or others essentially resulting in exchange of mutually beneficial favors (e.g. Klaphake 2006; Dombrowsky 2007; Qaddumi 2008).

Generally, such broad understanding makes cooperation possible virtually at all times and under any circumstances by multiplying cooperative opportunities (Sadoff and Grey 2002, 2005; Phillips et al. 2006, 2008; Phillips 2009).

1.2.2 Potential disadvantages of benefit sharing

Disadvantages of benefit sharing are largely overlooked in the literature. Even the title of the concept includes the term "benefit" only and does not include the term "cost". There are at least four types of inter-connected risks which might seriously contribute to increased costs (costs to reach and implement an agreed arrangement or development) in the long run and hinder sustainability of benefit-sharing arrangements and agreements.

Does benefit sharing result in equitable sharing? First, benefit sharing does not directly address the distributional dilemma of transboundary water relations (Wolf 1999) and it is likely that it will only postpone disagreements over shares. As Sadoff et al. (2008: p.29) note historically "the benefits derived from water development have generally not been shared equitably". In calculating benefits, given the often-complex nature of shared water resources, the distributional problem might get further complicated, as the calculation of benefits would require additional consent between riparians at least on quantification methods where one would need to put agreed values to all types of benefits. Clearly, complexity increases with attempts to calculate non-economic benefits (see above Types 1, 3, 4). In addition to the unresolved issue of equitable and reasonable sharing between riparians, there is still not enough research on long-term implications of sharing benefits from developments towards local populations (Dombrowsky et al. 2014).

Does benefit sharing address environmental impact? History is rich in examples of how developments on shared river basins (e.g. irrigation, hydropower projects) led to degraded natural environments. Here, the risk emerges with the fact that the potential environmental impact from developments on shared waters is often not immediate and

therefore prone to be underestimated, especially when projects gain strategic importance for the national economies (Tarlock and Wouters 2007; Hensengerth et al. 2012). This can be also seen as a question of equitable sharing in the sense that addressing environmental impact is crucial for distribution of benefits across generations. Hensengerth et al. (2012) analyzing benefit sharing in five dams on transboundary rivers (Senegal, Columbia, Orange-Senqu, Nile and Zambezi) highlighted that "the neglect of negative social and environmental concern may lead to conflict and lengthy renegotiations at a later stage".

Does benefit sharing increase complexity? This specifically relates to issue linkages with other sectors and other basins. When one complex resource system is linked to other similarly complex resource systems, difficulties in enforcement of agreed arrangements might impede realization of the intended benefits. Transaction costs normally increase when there are more parties involved already during negotiation, with greater scope of issues and larger group of actors and users involved, implementation will become costlier requiring increased coordination.

Does benefit sharing prevent abuse of power? Riparians might be tempted by what can appear as short-term benefits and agree to arrangements that can pre-define or limit the range of decisions in the long term. A riparian with a more advantageous position on some issues might impose its solutions on other issues (Dombrowsky 2007). A recent study (Tawfik 2015) on the Grand Ethiopian Renaissance Dam (GERD) concluded that the new dam seen as a project with shared benefits might significantly shift the balance of power within the Nile, however, might not necessarily result in establishment of an equitable regime. In addition, in relation to the previous risks, it seems it is still unclear whether and how the GERD will address the potential negative impact on the lives of affected population downstream as well as potential environmental consequences.

Overall, the potential disadvantages associated with benefit sharing are related to implementation – sustaining cooperation and benefits thereof, as the approach itself is rather focused on achieving or facilitating cooperation. The latter also can be seen from the fact that the earlier mutual gains approach (Fisher and Ury 1981) focused on achieving "yes" in negotiation with much less emphasis on implementation of agreed terms.

1.3 The specifics of transboundary water challenges in the Ferghana Valley, the Syr Darya Basin of Central Asia

The Syr Darya is one of the two large rivers in the Aral Sea basin in Central Asia, which Raskin et al. (1992: 57) described as "one of the most complicated human water development systems in the world". The river basin is shared among Kazakhstan,

Kyrgyzstan, Tajikistan and Uzbekistan and is often analyzed according to "water-use regions" or "irrigation districts" (Fig. 1.2). The river originates in the east within the mountainous territories of Kyrgyzstan, two main tributaries – Naryn and Karadarya – cross to Uzbekistan and form the Syr Darya river which then flows through Tajikistan before returning to Uzbekistan. Finally, from Uzbekistan, the Syr Darya crosses to Kazakhstan and continues till it reaches the northern part of the Aral Sea. The causes and factors for emerging transboundary disagreements, including classic examples such as competition to expand irrigated lands, upstream hydropower versus downstream irrigation interests, role of institutional settings and third party organizations have been studied in great depth (Abbink et al. 2009; Antipova et al. 2002; Dinar et al. 2007; Granit et al. 2010; Keith and McKinney 1997; Linn et al. 2005; Micklin 2007; PA Consulting 2002; Raskin et al. 1992; Sharma et al. 2004a, 2004b; Teasley and McKinney 2011; UNDP 2009; UNECE 2011; Frenken 2013).

Fig. 1.2. The Syr Darya River Basin and the Ferghana Valley

The major source of disagreements lies around operation of the Toktogul Reservoir (with active storage capacity of 14 billion cubic meters) located in the territory of upstream Kyrgyzstan. Constructed when all of the basin countries were part of the Soviet Union (or Union of Soviet Socialistic Republics – USSR), the Toktogul was planned to work in an irrigation mode – storing in winter and releasing in summer. After the collapse of the Soviet Union and independence of the Republics in 1991, upstream Kyrgyzstan suffering from severe winter energy deficits unilaterally started to operate the Toktogul in an energy mode – releasing more in winter (Fig. 1.3) which resulted in fundamental changes in seasonal proportions of releases (Fig. 1.4). That was despite the agreement of the Central Asian states from 1992 to adhere to the pre-independence arrangements. Obviously, the change to the energy mode had serious implications for downstream irrigation.

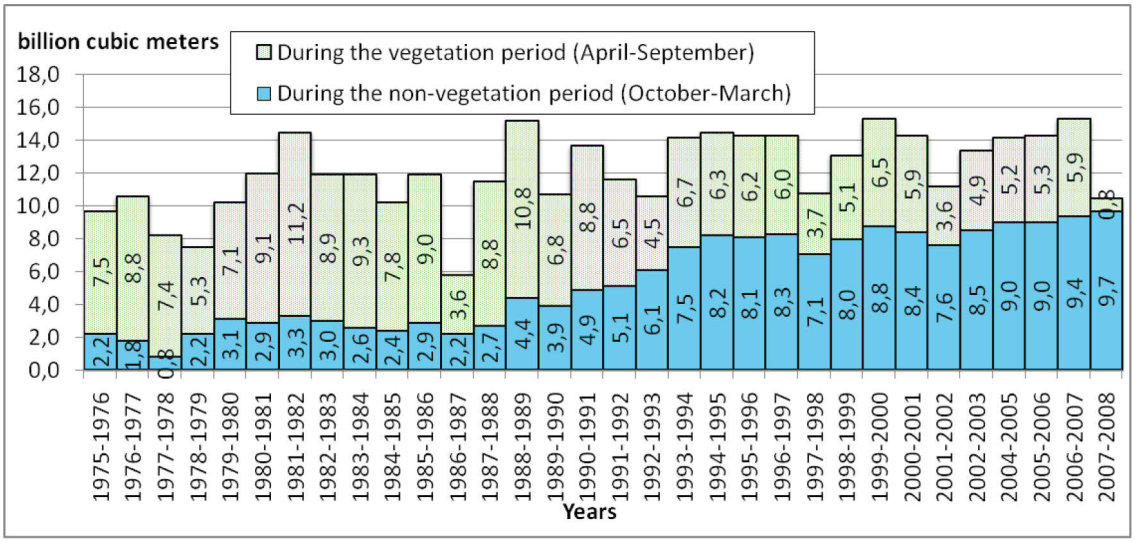

Fig. 1.3. Seasonal dynamics in releases from the Toktogul Reservoir between 1975 and 2008. Source: Sokolov (2015)

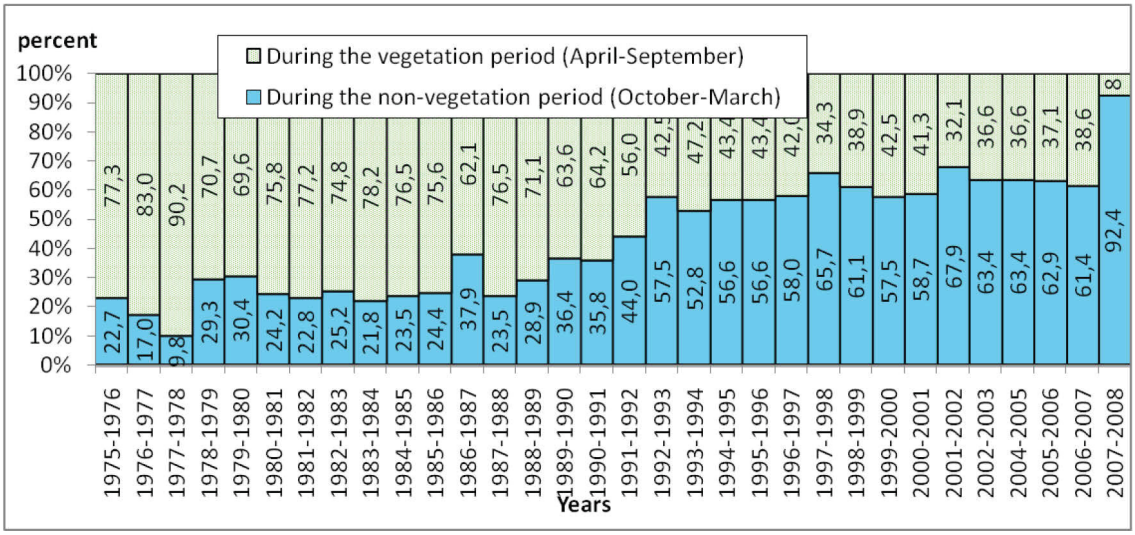

Fig. 1.4. Seasonal dynamics in releases from the Toktogul Reservoir between 1975 and 2008 in proportions. Source: Sokolov (2015)

A new Syr Darya Framework Agreement was concluded in 1998, whereby it was agreed that downstream Kazakhstan and Uzbekistan would purchase from Kyrgyzstan electricity produced during summer and provide gas to Kyrgyzstan during winter as compensation. Tajikistan joined the agreement in 1999. Although the 1998 Agreement was seen as a successful step at the beginning, the states could not agree on price mechanisms and perceptions increasingly differed as to what constitutes a reasonable arrangement.

Recently cooperative solutions have been suggested to balance the upstream energy and downstream irrigation needs of the riparians in the Syr Darya basin through new benefit sharing options (Teasley and McKinney 2011). However, implementation of these

options is seen problematic as the suggested solutions lack analysis at least in two important dimensions: analysis of sub-national level relations and historical-institutional developments affecting the present transboundary water interaction in the basin.

Recent research has brought attention to a great concentration of small transboundary tributaries (STTs) and small transboundary infrastructure (canals, pump stations and small reservoirs) in the Ferghana Valley of the Syr Darya Basin (Dukhovny et al. 2011; Wegerich et al. 2012a; Wegerich et al. 2012b; Wegerich et al. 2012c; Pak et al. 2014; Pak and Wegerich 2014; Platonov et al. 2014; Wegerich 2014). The research findings highlighted that there was a "significant difference between the centre [national level and main basin] and the periphery [the meso or province level and small transboundary tributaries and infrastructure]" (Wegerich et al. 2012a: 541). Cooperation on the meso level was not seen as problematic as at the national level. In addition, because of the complex geographic situation there is overall no clear up- and downstream distinction possible, but rather a geographic unity of highly interdependent and interlinked infrastructure (Wegerich et al. 2012b).

Nevertheless, it is possible to distinguish according to some sub-units which coincide neither with national nor with former irrigation district boundaries (Wegerich et al. 2012c). The research showed cooperation on transboundary infrastructure (operation and maintenance), compensation from different transboundary sources, electricity transfers and property rights on infrastructure. As one of the main challenges, the research identified the absence of a clear legal basis and border crossing (Wegerich et al. 2012a, 2012c). The study of Pak et al. (2014) drew attention to the historic development of conflicts and cooperation on one STT, the Isfara river. The research highlighted that because of upstream agricultural development agreements were often changed and adaptive solutions were mainly found in water compensation from other sources. Hence, the complexity of water infrastructure and water sharing increased. Because agreements were highly specific (in terms of water sharing) as well as the technical capability and overall water control were not sufficiently advanced the agreements failed.

Further, Pak and Wegerich (2014) explored the history of transboundary infrastructure development with a focus on small and medium dams within the Ferghana Valley. The research highlighted that demand for new infrastructure was driven by the riparian states and involved land exchanges, but also complex structures of separating land ownership from property ownership of infrastructure. Hence, already during the Soviet Union republican borders mattered. Overall, the existing research emphasized the need for analysis of the big picture integrating understanding of sharing arrangements on wider international and national levels with those on a lower province level.

1.4 Framework of multi-level institutional analysis

It has been argued that institutions, understood as both formal and informal "rules in use" often determine whether and to what extent benefits from cooperation can be realized as intended, and whether the risks can be managed effectively (Ostrom 1990; North 1990; Williamson 1998). An example is demonstrated by Dombrowsky (2009) who analyzed conditions related to property rights to see whether benefit sharing can cope with the challenges of international water law. Sadoff and Grey (2005) acknowledge the fundamental principles of international water law — equitable and reasonable use — first established in the 1966 Helsinki Rules and codified in the 1997 United Nations (UN) Convention on the Law of the Non-navigable Uses of International Watercourses. However, they propose the benefit sharing approach as an alternative. Dombrowsky (2009) disproved it as an alternative approach showing the importance of underlying property rights if mutual benefits to be achieved and suggested that the approach could be rather complementary in certain cases. However, Dombrowsky (2009) analyzes property rights only and there is still little research on a broader set of institutions affecting benefit sharing.

In this study, institutional analysis is applied to understand whether institutional environment is set "right" for effective implementation of agreed benefit-sharing arrangements and developments. Several scholars highlighted importance of distinguishing between different levels of institutions (e.g. Ostrom 1990; Williamson 1998; Pahl-Wostl 2009). Works by Ostrom explain that there are operational institutions for day-to-day operation, policy institutions defining/affecting rules for operational institutions and constitutional institutions – decision-making for policy institutions (Ostrom 1990, 2005). Ostrom has effectively disproved Hardin's model on tragedy of commons showing that the level of analysis was limited to the operational level (Ostrom 1990). North (1990, 1995, 2005) also emphasized the need to study complex problems on more than any single analytical level to make developments and policies effective.

While most of institutional analysis of this thesis builds on these works collectively, specific attention is given to Williamson's (1998) framework of analytical levels due to its emphasis on transaction costs that can explain costs associated with benefit sharing (Chapter 2) and suggested time horizons (which to the author's knowledge are not explicitly suggested by others). Williamson's (1998) framework distinguishes four levels of institutional analysis along with approximate frequency at which these institutions are established. These are informal institutions such as customs, traditions, norms – (highest) Level 1, formal institutions defining the rules such as polity, autonomy in decision-making and property rights – Level 2, governance institutions such as formation of main principles and organizations – Level 3, institutions for resource efficiency such as incentives to continuously improve marginal benefits– (lowest) Level 4.

Using such multi-level analysis is advantageous at least for the following reasons. First, it allows an adequate processing of the level of complexity faced in managing shared water resources. Along the property rights associated with water and land resources as well as infrastructure, it will be possible to examine a broader inventory of institutional arrangements and their influence on benefit sharing. Second, it allows combining social, environmental, economic, legal as well as power perspectives in analysis. Finally, it allows integrating the crucial long-time perspective that studies on benefit sharing have generally lacked by far.

1.5 Thesis objective and outline

The objective of this thesis is to investigate applicability of benefit sharing approach to managing shared water resources in the Ferghana Valley, the Syr Darya basin. The fundamental research questions are: what institutional conditions, how and why affect benefits and benefit sharing in managing shared water resources and what are the implications from short and long term perspectives?

To answer these questions research consisting of several steps has been undertaken. First, having studied the available literature in the field (see Section 1.1 through 1.4) efforts have been made to acquire data which would allow building a maximum level of knowledge regarding present and past transboundary water relations in Central Asia with particular focus on the study area – the Ferghana Valley, the Syr Darya basin. Second, having acquired a large collection of data, an analysis has been conducted to trace the origins of the institutional arrangements affecting water and land developments with shared benefits. Third, implications of identified institutional arrangements are studied in respect to the costs of transboundary benefit sharing as well as related to water security in the Syr Darya basin. Fourth, based on the concept of path dependency changes in formal and de-facto allocation decisions are studied to understand what drivers determine the degree of change in riparian water allocation.

Each chapter of the thesis addresses a specific set of research questions. The questions are provided below followed by a short overview of the corresponding chapter.

What are the existing institutional arrangements affecting the current state of transboundary water relationship and benefit sharing in the Ferghana Valley? What are the types and forms of benefit sharing and cost implications for sustainability of transboundary cooperation in the long run? (Chapter 2)

Chapter 2 of this thesis traces back the origins of the institutional arrangements shaping the current transboundary water relationship in the Ferghana Valley and Syr Darya basin and argues that ignoring long-term relationship among riparians on the sub-national level has been a significant obstacle in realization of the newer benefit sharing

options. Clear definition of property rights and "rules in use" is a necessary condition if benefits from cooperation are to be realized as intended (Ostrom 2009; Dombrowsky 2007). Chapter 2 brings forward rich details of polycentric relationship by analyzing long-term record of fierce negotiations and cooperation among riparians on water and land sharing arrangements in the Ferghana Valley for the period between 1917 and 2013. Agreements reached in different periods and patterns of implementation are analyzed to reveal existing qualities of multi-level institutional structure governing transboundary water relations.

What are the factors determining sustainable water security? Are issue linkages among water, energy and food sectors through a nexus approach helpful for achieving sustainable water security? What are the implications of demand and supply side water security in the Syr Darya basin? (Chapter 3)

The importance of water security has gained prominence on the international water agenda, but the focus seems to be directed towards water demand. An essential element of water security is the functioning of public organizations responsible for water supply through direct and indirect security approaches. Despite this, there has been a tendency to overlook the water security strategies of these organizations as well as constraints on their operation. Chapter 3 discusses the critical role of water supply in achieving sustainable water security and presents two case studies from the Syr Darya basin on the management of water supply for irrigated agriculture. The analysis concludes that existing water supply bureaucracies need to be revitalized to effectively address key challenges in water security.

What are the cost implications from issue linkages and compensation mechanisms in a complex institutional environment? (Chapter 4)

While in the international literature water sharing in the Syr Darya Basin per past agreements is widely portrayed as most benefiting Uzbekistan, here the dynamics of water allocation within small transboundary tributaries in Ferghana Province show Uzbekistan as benefiting least. The case study highlights that water allocation for Uzbekistan within the tributaries has decreased over the years. Uzbekistan's approach to compensate for the reduced allocations by means of other water sources has had large long-term cost implications for irrigated agriculture as well as the irrigation bureaucracy. Chapter 4 carries on with contributing to the international debate on benefit sharing in transboundary rivers. It highlights that costs should be incorporated into the benefit-sharing approach, and therefore the focus on benefit sharing alone is misguiding riparian states. Furthermore, Chapter 4 raises the need to reevaluate benefits, since perceptions of potential benefits change over time.

How does 'baggage' in riparian relationship affect implementation of new allocation agreements in adapting to new needs and challenges? (Chapter 5)

The purpose of Chapter 5 is to analyze how socio-economic and techno-ecological characteristics can lead to three different degrees of response in riparian water sharing in the long run. A longitudinal study of five rivers in the Ferghana Valley is presented to understand how riparians responded when they faced pressure to reallocate. The impact of path dependency on the dynamics in transboundary water allocations is studied in a systematic way. Therewith drivers of pressure that trigger a new formal agreement are differentiated from sources of path dependency that lead to either pent-up pressure of not even willingness to agree to a formal regulation or the resistance in the de-facto implementation of the agreement. The analysis reveals three key sources of path dependency: (i) vested interests, (ii) infrastructure control and (iii) network effects which form the so called 'baggage' in relationship. Chapter 5 discusses the interplay among these sources and corresponding impact on the short- and long-term outcomes. Understanding of the existing 'baggage' in relations allows making predictions about a likely degree of change or negotiation outcome under a certain combination of socio-economic characteristics and institutional environment.

The remainder of the thesis is structured in the following way. Chapter 2 introduces to the rich details of the study area and conceptualizes the costs of benefit sharing in transboundary water management with evidence from the Ferghana Valley. It is followed by Chapter 3 which examines water security in the Syr Darya basin. Chapter 4 provides a cost perspective on developments of lift irrigation as a result of earlier benefit sharing arrangements and how these developments became unsustainable in the long run. Chapter 5 identifies the impact of path dependency on transboundary water allocation in a systematic way to be able to understand what makes reallocation a success. Then the final chapter synthesizes findings of the research, discusses the major implications for the set questions of the thesis and provides the author's vision for future research.

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2 The Costs of Benefit Sharing: Historical and Institutional Analysis of Shared Water Development in the Ferghana Valley, the Syr Darya Basin

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The Costs of Benefit Sharing: Historical and Institutional Analysis of Shared Water Development in the Ferghana Valley, the Syr Darya Basin

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Abstract: Ongoing discussions on water-energy-food nexus generally lack a historical perspective and more rigorous institutional analysis. Scrutinizing a relatively mature benefit sharing approach in the context of transboundary water management, the study shows how such analysis can be implemented to facilitate understanding in an environment of high institutional and resource complexity. Similar to system perspective within nexus, benefit sharing is viewed as a positive sum approach capable of facilitating cooperation among riparian parties by shifting the focus from the quantities of water to benefits derivable from its use and allocation. While shared benefits from use and allocation are logical corollary of the most fundamental principles of international water law, there are still many controversies as to the conditions under which benefit sharing could serve best as an approach. Recently, the approach has been receiving wider attention in the literature and is increasingly applied in various basins to enhance negotiations. However, relatively little attention has been paid to the costs associated with benefit sharing, particularly in the long run. The study provides a number of concerns that have been likely overlooked in the literature and examines the approach in the case of the Ferghana Valley shared by Kyrgyzstan, Tajikistan and Uzbekistan utilizing data for the period from 1917 to 2013. Institutional analysis traces back the origins of property rights of the transboundary infrastructure, shows cooperative activities and fierce negotiations on various governance levels. The research discusses

implications of the findings for the nexus debate and unveils at least four types of costs associated with benefit sharing: (1) Costs related to equity of sharing (horizontal and vertical); (2) Costs to the environment; (3) Transaction costs and risks of losing water control; and (4) Costs as a result of likely misuse of issue linkages.

Keywords: transboundary water cooperation; equity; environment; water governance; issue linkage; institutions; Central Asia

1. Introduction

In order to promote cooperation over shared water resources, it is important to highlight the potential for cooperation including the broadest range of possible projects and benefits, options and choices available to riparian parties. In doing so, institutional analysis can be helpful to identify both the accepted norms, traditions, rules, principles and the modes of cooperation [1–3] which could generate greatest net as well as individual benefits [4–11]. This study reviews the benefit sharing approach in the context of international water management from institutional economic, social, environmental as well as power relations perspectives. The major advantage of benefit sharing is its capacity to facilitate cooperation among riparian parties by redirecting the focus from quantities of water to benefits derivable through its use and allocation and therefore turning the zero sum game into a positive sum interaction [4–11].

The article looks into historical data to derive lessons for potential application of benefit sharing in case of the Ferghana Valley, located in the upstream of the Syr Darya Basin and shared by Kyrgyzstan, Tajikistan and Uzbekistan. The Valley is rich in transboundary water resources along with shared infrastructure and because of the unity within one country in the past (until 1991 the republics were soviet socialist republics (SSRs), part of the Union of Soviet Socialistic Republics (USSR), the republics have a long history of relationship of initiating, implementing and maintaining the existing infrastructure on various governance levels. We are mindful that the benefit sharing approach was proposed for promoting cooperation among independent states, whereas the analysis in this article covers a period prior to independence. This is done to allow deriving lessons for the countries in the long run, at the same time possibly adding value to the research in application of the approach to riparians, which are part of a federal structure as it was in case of the Soviet Union or are countries in transition.

Although debates on benefit sharing are not as young as those on water-energy-food nexus (e.g., [12,13]), both seem to lack a rigorous historical and institutional perspective. This is at the very core of our manuscript and the analytical approach presented here attempts to fill this gap and expand understanding of the role of institutional settings in shaping the scope and effect of management decisions while viewing these decisions as a process.

The article continues with providing an overview on benefit sharing, which is followed by a background and methodology section. The analysis of the data has shown that there were five distinctive periods, each with a significant shift in the way benefits from the shared water resources were shared influenced by development of different formal and informal institutions (property rights, autonomy in decision-making, sharing criteria, changes and interaction in governance institutions, interests and priorities on different levels). While the prevailing approach has been to look at developments as before

and after independence, findings of our research reveal the value of taking a more detailed look. The results section is therefore structured into these five distinctive periods. Further, the discussion section elaborates on major findings and attempts to systematize them. In the final section key conclusions are provided on implications of the research on broader scholarship of managing shared water resources as well as on possible constructive changes specifically in the Central Asian context.

2. Benefit Sharing—An Overview

In managing shared water resources, benefit sharing has been increasingly proposed as an approach to move from unilateral to cooperative actions by showing greater benefits of doing so. The approach not only redirects attention from volumes of water to benefits related to water, but also from pre-existing tensions or disagreements to new developments and arrangements. However, for sustainability of positive sum, it is central to ensure that the redirection of attention does not result in ignoring or worsening of problems, overweighing benefits in the long run. To understand the power of the benefit sharing approach to make cooperation more attractive one has to clarify: (1) *What benefits are there?* (2) *How can they be shared?* (3) *What are the costs of achieving shared benefits?*

Several studies define and categorize benefits and benefit sharing as follows.

Sadoff and Grey [4] determined four categories of benefits associated with cooperation as environmental (Type 1), with increasing benefits to the river; economic (Type 2), with increasing benefits from the river; political (Type 3), with reducing costs because of the river; and catalytic (Type 4), with increasing benefits beyond the river. The main critique on the typology is its practicality [10,14–17] as well as weakness in prioritization or identification of entry points. The latter is addressed by Phillips [8] whose methodology (Transboundary Waters Opportunity (TWO) Analysis) helps to see areas of priority when brainstormed by riparians. Overall, most scholars agree on the typology [4] as it covers the whole spectrum and allows distinguishing directions for cooperation.

Further, Sadoff and Grey [5] (p.3) define "benefit sharing" as "*any action designed to change the allocation of costs and benefits associated with cooperation*". The term "any action" can be interpreted as hindering but also enabling factor of the definition, since it broadens the spectrum of processes beyond the water sector [8–11,17,18]. Sadoff and Grey [5] acknowledge the fundamental principles of international water law—equitable and reasonable use—first established in the 1966 Helsinki Rules and then codified in the 1997 United Nations (UN) Convention on the Law of the Non-navigable Uses of International Watercourses. However, they propose the benefit sharing approach as an alternative. Dombrowsky [19] disproved it as an alternative approach showing the importance of underlying property rights if mutual benefits to be achieved and suggested that the approach could be rather complementary in certain cases. This is captured by a more specific definition suggested by Phillips and Woodhouse cited in [20] (p. 1): "*…as the process where riparians cooperate in optimising and equitably dividing the goods, products and services connected directly or indirectly to the watercourse, or arising from the use of its waters*."

Later, Sadoff *et al*. [21] (pp. 28–29) explaining "*fair sharing of benefits*" refer to Article 6 of the 1997 UN Convention, which enumerates seven non-weighted guiding principles. Theoretically, this seems to translate the already existing dilemma of equitable distribution in the traditional (water volume based) approach into the benefit sharing approach. From practical perspective, Sadoff *et al*. [21] suggest

learning from the actual practices derived from existing international treaties related to management of shared water resources as a starting point of negotiations referring to the database of transboundary agreements developed by Wolf [22]. However, the authors admit that "*the benefits derived from water development have generally not been shared equitably*" [21] (p. 29). The approach seems to be rather future oriented focusing on *ex ante* conceptualization of possible options to facilitate cooperation.

More broadly, the idea of benefit sharing [4,5] seems to replicate the mutual gains approach of the negotiation research introduced earlier [23]. However, one should acknowledge that both strongly relate to and based on the utilitarian concepts of the game theory and welfare economics, particularly to the problems looking for a Pareto improvement. However, unlike the game theoretic concepts, literature on both benefit sharing and mutual gains go beyond computing possibilities and show enthusiasm calling for creativity in problem solving, thinking beyond quantities, issues at the table, sectors involved, and assumptions. While encouragement for cooperation is supported by all means here, the question arises whether the increased emphasis to cooperate and achieve "yes" in a negotiation might overshadow or even cause some possible crucial negative consequences. Especially in a complex environment of shared water resources, broadening the basket and bringing in other, often as complex, issues, thus merging two or more complex resource systems, might easily lead to increased transaction costs by creating even a greater number of potentially conflicting interactions in a longer period.

The original mutual gains approach [23] addresses such questions as risks and circumstances under which one should not agree to a deal. In contrast, the studies testing the applicability of the mutual gains as well as benefit sharing in managing shared water resources seem to lack this holistic view. In fact, one of few available studies specifically on mutual gains in international rivers by Grzybowski *et al*. [24] promotes the benefits of the approach (also see: Special Issue "Getting to Yes" in United States–Canadian Water Disputes ed. by Sewell and Utton in 1986 [25]). That study, with a strong international law perspective, provides the case of the Columbia River Basin as one of the successful cases. Although, unlike Sadoff and Grey [5] and similar to Dombrowsky [19], Grzybowski *et al*. [24] argue that the mutual gains approach is complementary to the fundamental principles of international water law, *i.e.*, equitable and reasonable use, prevention of significant harm and obligation to cooperate. However, another paper, with as strong legal perspective [26], views benefit sharing as an artificial substitute to the traditional water sharing approach and concludes that in the long run the Columbia River Treaty could be questioned both on the grounds of equity of sharing and the costs to the environment.

Furthermore, focusing not only on the benefits but also on the costs of the benefit sharing approach, Dombrowsky [19] reveals a number of essential pre-conditions for benefit sharing to be successful. These include clear property rights and enforcement mechanisms, both of which are often problematic, as well as compensatory pay-off structures. However, Dombrowsky [19] seems to look into options to cooperate mostly during the negotiation process, with little emphasis on implementation and assuming that the coordination as well as operation and maintenance come at no cost.

Philips [8] (p. 14) specifically focusing on a practical application with the TWO Analysis mentions "*it [TWO Analysis] also assists markedly in defusing any pre-existing tendencies of riparians in relation to conflict*". Defusing pre-existing tendencies of riparians in relation to conflict is indeed an advantage of benefit sharing, but it might also be its disadvantage if a riparian has to give up on a critical matter in order to gain immediate (however important those can be) benefits. Hence, what appear to be missing are possible longer-term implications. As Tarlock and Wouters [26] (p. 524) reason, focusing on benefits

might result in "*unequal bargaining among states; the premature "sale" of future use opportunities; and the increased risk of aquatic ecosystem degradation*". Riparians might be tempted by what can appear as short-term benefits and agree to arrangements that can pre-define or limit the range of decisions in a longer term.

Another study by Dombrowsky *et al*. [27] seems to acknowledge the problem of implementation in a different context, findings of which support the mentioned concerns [26]. Already looking at projects in preparation stages, they provide an example of how, due to "*unforeseen effects*" or because "*some things did not work as it was planned*", the project-affected population became less satisfied with fairness of compensations provided for resettlement [27] (p. 1096). Concerns of the authors over implications of benefit sharing internationally and locally are timely, but long-term implementation still remains unexplored.

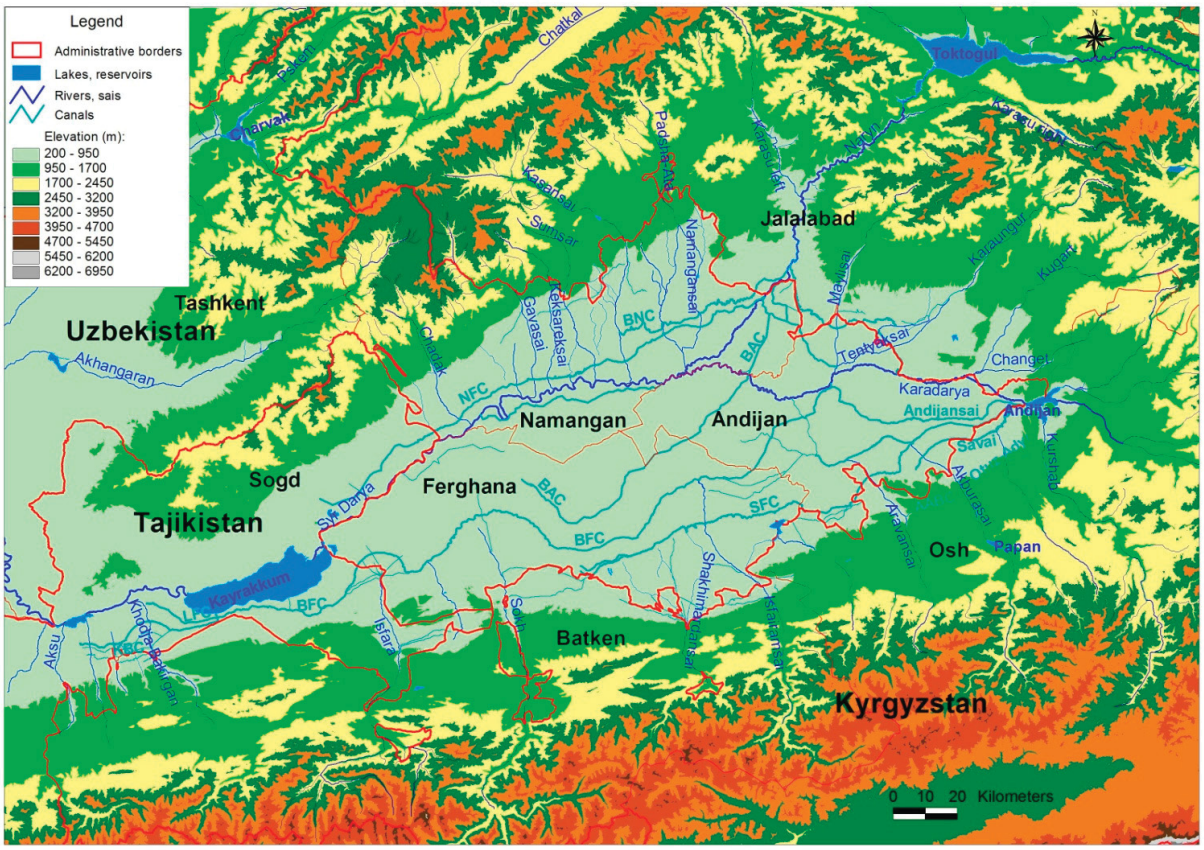
Overall, the long-term problems related to benefit sharing could be summarized as (1) inequitable allocation of benefits (internationally and locally, respectively; thereinafter, horizontal and vertical, respectively) as well as (2) likely underestimation of costs to the environment and related implications which are often not immediate [26]. Tarlock and Wouters [26] by benefit sharing refer to monetary compensation in return for a compromise in a shared river basin development (hydropower dams, the Case of Columbia River Treaty between the United States and Canada) or allocation (barter agreements, the Case of the Aral Sea Basin). What is not addressed is another form of benefit sharing—issue linkages. Even though issue linkage can be seen as an in-kind form of compensation, there seem to be two possible problems specifically related to issue linkages: (1) Increased transaction costs and more difficult control over implementation of the agreed terms; and (2) Possible use of issue linkages by a more advantaged party to impose its solution on other issues [9].

Similarly, Hensengerth *et al*. [11] conceptualizing benefit sharing on dams in transboundary rivers and analyzing five dams highlighted that "*the neglect of negative social and environmental concern may lead to conflict and lengthy renegotiations at a later stage*". They also touched upon the importance of "*a history of cooperation between basin states and of institutionalized cooperation*" as a factor influencing benefit sharing [11] (p. 27). The paper attempts to expand this framework by systematic identification of the costs of benefit sharing as an approach in the long run as well as further exploring the idea that taking these costs into account is important to make cooperation more sustainable, including in river basins with history of cooperation and institutions to build on.

3. Background and Methodology

3.1. Study Area

While the central part of the Ferghana Valley lies mainly within the territory of Uzbekistan, the surrounding mountainous slopes are mostly part of Kyrgyzstan and Tajikistan (Figure 1). More specifically, the Ferghana Valley covers the territories of 7 administrative units (provinces): parts of Batken, Jalalabad and Osh Provinces of Kyrgyzstan, Sogd Province of Tajikistan as well as the entire territories of Andijan, Ferghana and Namangan Provinces of Uzbekistan. The 7 provinces have a total area of 124,000 km^2 and a population of about 14 million people, which is more than 20% of the whole population of Central Asia.



AABC - Aravan-Akbura Canal, BAC - Big Andijan Canal, BFC - Big Ferghana Canal, BNC - Big Namangan Canal, KBC - Khodja-Bakirgan Canal, NFC - North Ferghana Canal, SFC - South Ferghana

Figure 1. Topography, transboundary water resources and infrastructure in the Ferghana Valley (map by Alexander Platonov, 2015; courtesy of the International Water Management Institute).

The transboundary water resources of the valley consist of the Syr Darya, with an annual average flow of 37 billion cubic meters (BCM), formed from the confluence of the Naryn (13.8 BCM) and Karadarya (3.9 BCM), both of which originate in the mountains of Kyrgyzstan [28]. The flow of the Naryn River is regulated by the Toktogul Reservoir (14 BCM active storage capacity), located upstream in the territory of Kyrgyzstan, and the flow of the Karadarya by the Andijan Reservoir (1.75 BCM active storage capacity), which is on the border between Osh Province of Kyrgyzstan and Andijan Province of Uzbekistan. When exiting the Ferghana Valley, the Syr Darya is regulated by the Kayrakkum Reservoir (2.6 BCM active storage capacity), located in the territory of Tajikistan. Within the valley, there are also about 20 Small Transboundary Tributaries (STTs) with significant combined contribution to the flow of the main stem of 7.8 BCM [29]. Often these STTs have their own smaller reservoirs [30].

According to the Scientific Information Center of the Interstate Commission for Water Coordination (SIC ICWC) [31], the total irrigated area under command of irrigation canals in the Valley is 1.3 million ha (no data provided for Batken province). The breakdown on population, territories and irrigated lands by the countries and their associated provinces are presented in Table 1. The main economic activities

are agriculture and livestock. The main crops are cotton, wheat, maize, orchards, tobacco, rice and vegetables in irrigated farming [31,32].

Table 1. Brief information on the Ferghana Valley, upstream of the Syr Darya Basin.

Country	Province	Population, Inhabitants	Population Density, Inhabitants/km^2	Territory, km^2	Irrigated Lands Data for 2010 [31], Thousand ha
Kyrgyzstan (KG)	Batken	469,700 Data for 2012 [33]	27.6	17,000 [34]	no data
	Jalalabad	1,099,200 [35]	31.6	33,700 [35]	125.6
	Osh	1,199,900 [36]	41.1	29,200 [36]	126.8
Sub-total (KG)		2,768,800	34.7	79,900	252.4
Tajikistan (TJ)	Sogd	2,349,000 Data for the period 2000–2010 [37]	93.2	25,200 Data for the period 2000–2010 [37]	178.0
Sub-total (TJ)		2,349,000	93.2	25,200	178.0
Uzbekistan (UZ)	Andijan	2,805,500 As of 1 January 2014 [38]	668.0	4,200 [39]	269.5
	Ferghana	3,386,500 As of 1 January 2014 [38]	498.0	6,800 [39]	357.7
	Namangan	2,504,100 As of 1 January 2014 [38]	316.0	7,900 [39]	282.1
Sub-total (UZ)		8,696,100	460.1	18,900	909.3
Total		13,813,900	111.4	124,000	1,339.7

3.2. Data

The data were gathered through archival research during several projects of the International Water Management Institute between 2010 and present (see acknowledgment). The specific geographical focus is on the relationship between Osh Province of Kyrgyzstan and Andijan and Ferghana Provinces of Uzbekistan, however, developments in the neighboring provinces and republics are also studied to illustrate wider issues. Since we look at historical data, it should be noted that the current Jalalabad Province (established in 1939) was part of Osh Province between 1959 and 1990 [35], whereas Batken Province was established only in 1999, which, until then, had been part of Osh Province as well [34]. Similarly, Andijan and Namangan Provinces were established in 1941 and Namangan was part of Ferghana and Andijan Provinces between 1960 and 1967 [40,41].

The data mainly represent interactions between the republics signed or prepared to manage the shared land and water resources and other related matters as well as higher level (regional) laws, decrees, agreements, declarations, *etc*., reflected in 203 pieces of various documents covering the period between 1917 and 2013 (please see Tables S1 and S2). To refer to a specific document from Tables S1 and S2, the following acronyms are used in parenthesis [S1:N], where N is the corresponding number of the document as listed in the supplementary table (in this example, Table S1). In addition, the data with main characteristics of transboundary infrastructure were derived from the earlier studies of Wegerich *et al*. [28] for the smaller infrastructure (Table S3) as well as from the above documents and other sources for the larger infrastructure (Table 2).

3.3. Analytical Approach

The case study is based on in-depth qualitative analysis of the documents particularly from benefit sharing perspective: according to the types of benefits considered (Type 1, 2, 3 and 4) [4] and the ways sharing was envisioned, benefit-sharing mechanisms applied (compensations: monetary or in kind, issue linkages: outside or within water sector, across different basins), location of the object(s), property rights associated with the object(s), implementation of the agreed terms when relevant, and other information to see the connection and reference between the documents. Both direct costs of the developments and arrangements (such as cost of construction) and indirect costs of benefit sharing as an approach are analyzed.

The specific focus during the historical analysis was given to institutional changes. To be able to distinguish between different levels of institutions as well as to understand their level of development from temporal perspective it is referred to Williamson's [3] framework of institutional analysis: Informal institutions such as customs, traditions, norms—Level 1; Formal institutions defining the rules such as autonomy in decision-making and property rights—Level 2; Governance institutions such as formation of main principles and organizations—Level 3; and Institutions for resource efficiency such as incentives to continuously improve marginal benefits—Level 4. As a result of the analysis, five distinctive periods of benefit sharing were distinguished where significant shift in establishment of these institutions took place. The results of the analysis form the respective five sub-sections of the following section.

4. Results

4.1. From 1917 to 1953: Border Delimitation and Irrigation Development

During this period under Stalin's strong hand, benefit sharing between the republics was imposed by the central planning government in Moscow; there was no negotiation and benefits from projects involving riparians were shared *de facto*. The republics had only a symbolic autonomy in decision-making. However, the period marks developments, which would have crucial impacts on the types of benefits and the way those benefits would be shared later.

First, a complete nationalization of lands in 1917 [S1:1] was followed by border delimitation (till 1936) forming the new republics decision-making bodies, which eventually would become the present independent states. Due to the complexity of the landscape, varying economic potential, and mixed ethnicities across the valley, the sides had contesting claims and many border questions were left open [30,42–47].

Second, the extensive irrigation development placed emphasis on cotton independence of the USSR. The studies [28,30,31,42–48] indicate that the entire institutional setting was aimed at two types of benefits [4]. The increased agricultural production is assumed to have contributed to the region's economy directly (Type 2). The water infrastructure development was in line with the Soviets' agenda to restore social and political stability in the region by increasing employment and attempts to redirect the attention from political life to implementation of the projects. The combined effect can be classified as benefits beyond the water resources, Type 4.

Third, constructed irrigation canals created the foundations for property rights on the shared water infrastructure. The infrastructure was constructed in areas that were easier to irrigate (within the valley). Since water flows were mainly utilized by downstream collective farms (*kolkhozes* and *sovkhozes*) and

districts, the majority of the projects with shared command area were operated by the authorities in the Uzbek SSR, even though some were located upstream within the territories of the Kyrgyz or Tajik SSR (Table S3). This is the root of why some of the infrastructure with shared benefits within territories of Kyrgyzstan (and Tajikistan) today belong to Uzbekistan and occasionally *vice versa*.

Through 11 shared projects, the republics regulated the water resources with a command area of 57,542 ha (including 10,300 ha in the territory of the Kyrgyz SSR) (Table S3). In 3 out of 6 cases, the Kyrgyz SSR did not have any land irrigated despite the headwork/infrastructure location was in the Kyrgyz SSR. In addition to irrigation, pastures of the republics were re-distributed for long-term use. The data from 1946 indicate that the Uzbek SSR was the main recipient of pasturelands (4 million ha), while the Kyrgyz SSRs was the main provider of pasturelands (1.1 million ha), with a minor input from the Tajik SSR (71 thousand ha). This was connected to the greater number of Livestock Units (LSU) in the Uzbek part of the Ferghana Valley than in the Kyrgyz part: 0.3 million LSU and 0.2 million LSU, respectively.

The costs of construction of the shared infrastructure were financed through the budget of the Uzbek SSR, although the other republics had benefits too. In addition, during this period, a significant movement of labor force took place: first, forced migration before World War Two, second, massive resettlement during and after World War Two, which included highly qualified specialists from Russia and western parts of the USSR to Central Asia, especially Uzbekistan [42]. Thus, even without detailed data on the extent and proportions, it is evident the costs borne in providing the labor force for the construction and ameliorative works were colossal. In addition, the documents within this period do not prioritize environmental preservation or prevention of possible negative impact of the developments on available water quality and quantity.

4.2. From 1953 to 1970: Negotiation and Mega Projects to Boost Water Supply

The year 1953 marked the end of the Stalin period. Although the new leadership of the Soviet government continued with further policies to increase agricultural output, there were the following important differences influencing various aspects of benefit sharing.

First, the republics gradually started to gain autonomy in decision-making. Negotiations over the shares on several projects were held directly between the republics and explicitly documented within the Protocols. For example, after the start of the works on the Toktogul Reservoir, the Kyrgyz SSR claimed and secured compensation for the lands allocated for it through negotiations on the Andijan Reservoir [S1:30] (more details follow). At the same time, the share of the Kyrgyz SSR in the allocated pasturelands increased significantly too, amounting to 834 thousand ha (328% increase compared to 1946) without decreasing the areas allocated to the other republics [S1:8]. Later, the autonomy increased with the 1968 Union-Wide Law on Land, which called for direct dispute resolution between the republics [S1:34].

Second, in 1953–1970, negotiations and construction works of several larger projects were initiated, which led to a sharp increase in issue linkages and closed the basin in the long run (Table 2).

Table 2. Projects with shared benefits in the Ferghana Valley initiated/constructed between 1953 and 1970.

Project	Negotiation	Commissioning	Irrigation Benefits: Command Area, thousand ha (and/or Share in Water Allocation, %)			Other Benefits
			Uzbek SSR	Kyrgyz SSR	Tajik SSR	
Kayrakkum Reservoir with the active capacity of 1.7 (BCM) on the Syr Darya River [49]	Late 1940s–1950s	1956	At the exit of the Ferghana Valley, benefiting the downstream of the Valley and contributing to 185.3 thousand ha of the Tajik irrigated lands in the Syr Darya Basin [49]. Six thousand hectares in the Arka Massive of the Kyrgyz SSR through pump-stations in the Tajik SSR			No initial data. "For the period of 1990–1998, the Kairakkum hydroelectric power station annually generated about 323 million kWh on average in the growing season" [49] (p. 115).
Toktogul Reservoir (14 BCM of active capacity) on the Naryn River	no data (assumed in late 1950s)	1974	Built for long-term regulation of the Naryn flow. Water supply increase for 918 thousand ha, expansion by 400 thousand ha in the Syr Darya River Basin (exact shares of the republics were not possible to calculate) [50]			Hydropower (4.1 billion kWh a year) initially it was agreed that the flow released as a result of hydropower generation is allocated at the ratio of 85.5% for the Uzbek SSR and 14.5% for the Kyrgyz SSR.
Left-shore Naryn Canal (18 m^3/s) and Druzhba pump-station	1960s	1969–1970	5.2	3.5	not applicable (n/a) due to its geographic location	–
Tortgul Reservoir on the Isfara STT (0.09 BCM)	1960s	1971	1.6, (8% water) [51] (p. 23).	9.23 (37% water)	21.3 (55% water)	Kyrgyz SSR and Tajik SSR share water from canal Machai (2 km upper than water intake to Tortgul Reservoir) on proportion of 80% and 20%, respectively [51] (p. 24).
Papan Reservoir (0.24 BCM of active capacity) on the Akburasai STT	1960s	1985 [S1:109]	26.6 [52]	10	n/a	1.5 m^3/s for domestic use of Osh city
Sokh Reservoir (0.32 BCM of active capacity) on the Sokh STT [S1:83]	1960s	Not completed	45.2	18.2	n/a	Compensation for lands provided for the construction of the Toktogul Reservoir. The reservoir would increase its irrigated lands in the Burgandy Massive by 22,000 ha (with 0.2 BCM from the reservoir) in the Kyrgyz SSR and increase water supply for the existing irrigated lands in the Uzbek SSR.
Karkidon Reservoir (0.22 BCM)	1961	1968	87% water	13% water	n/a	–
Andijan Reservoir (1.75 BCM of active capacity) on the Karadarya	1962	1978	247.1	49.6	n/a	Unlimited expansion upstream of the reservoir for the Kyrgyz SSR, hydropower release from the Nurek Reservoir (on the Amu Darya Basin) 85.5% for the Uzbek SSR, 14.5% for the Kyrgyz SSR.
Left-shore Kampyr-Ravat (LSKR) Canal	1965	Not constructed	15.9	8	n/a	Project not implemented.
Right-shore Kampyr-Ravat (RSKR) Canal	1965	1970s	14.57	–	n/a	–
Kasansai Reservoir (0.3 BCM) on the Kasansai STT [S1:83]	1967 (second phase)	1972	28.8	1.3	n/a	–

The table shows issue linkages of increased complexities both within and outside the basin. For the Kyrgyz SSR, who provided lands for the construction of the Toktogul Reservoir, in 1961, Moscow's idea was to compensate the lands by giving expansion rights (15,000 ha) and water for it in the Burgandy Massive through regulation of the Sokh River [S1:87]. However, in the 1962 negotiations of the Andijan Reservoir, the Kyrgyz SSR sought compensation directly from the Uzbek SSR by requesting construction of the Left-Shore Kampyr-Ravat Canal (LSKR) to the Burgandy Massive to irrigate additional 12,000 ha [S1:18]. The Uzbek SSR agreed to 8000 ha and that in addition to the LSKR Canal, the design of the Sokh Reservoir would take into account feeding these 8000 ha [S1:30].

The outcome of the period was that (1) the parties on all levels (regional, national, meso and local) were expecting significantly higher water supplies in the long term and therefore boost in irrigation expansion and (2) the agreed plans were rather ambitious and as was claimed in several cases, would exceed the capacities of the republics to implement the projects within agreed timeframes. In 1965 the Osh province Water Management Department (WMD) proposed to expedite the construction of the Toktogul, Andijan, Papan, Sokh, and Tortgul Reservoirs as water supply was not higher than 50% of water demand in the right shore tributaries of the Karadarya [S1:26]. The ambitious plans resulted in delays: transfer of land for the construction and their compensation were delayed due to administrative, technical and financial constraints [S1:56]. Some projects had delays for several decades, being only partially implemented (the Sokh Reservoir) or not implemented at all (the LSKR Canal). This had unfavorable implications for both sides. The Kyrgyz SSR was left without its expected increase in water supplies from these projects who prepared additional lands in advance [30]. Hence, incentives to look for compensation from other sources were created. The Uzbek SSR would, on the other hand, have to compensate for possible losses related to the latter and would have a weaker bargaining power in future negotiations with the Kyrgyz SSR (more details in the later periods).

The analyzed documents show the continued focus on the economic benefits, *i.e.*, increased water supply and right to expand irrigated agriculture as a result of joint infrastructure development. The costs of the smaller infrastructure were still covered through the budget of the Uzbek SSR (Table S3). There is lack of data on the detailed allocation of the costs of the Toktogul Reservoir. The construction of the Andijan, Karkidon, and Kasansai Reservoirs, Left-Shore Naryn Canal, as well as of not completed Sokh Reservoir and not implemented LSKR canal were the responsibilities of the Uzbek SSR while the Kyrgyz SSR was responsible to contribute with provision of lands for construction. While both monetary compensation, including payments to compensate losses related to population resettlement, and non-monetary compensation mechanisms were practiced within this period, the costs to the environment were still not considered.

4.3. 1970s: Competition, Allocation Criteria and Counter Hegemony

In 1970, the future of benefit sharing was significantly influenced by two important developments. The 1970 Order [S1:40] from Moscow allocated increased investments for further land reclamation as well as regulation and re-allocation of the runoff of the rivers for the next 15 years but pointed out the projects would be approved on a case by case basis. This meant official competition for the right to use land and water resources between the republics. On the other hand, the 1970 Union-Wide Law on Water

[S1:41] formalized the basin approach under which so called "Schemes" of complex use should have been developed for each river basin.

The initial version of the Syr Darya Scheme developed in the beginning of the 1970s [S1:42] (p. 5) explained the principle land and water allocation criteria as:

- Proximity of the lands to the source of irrigation;
- Higher productivity of the lands, lower demand for irrigation, less investments and time;
- Preference for the lands in more southern latitudes suitable for more valuable sorts of cotton;
- Proximity of the lands to the reserve contingents (labor, infrastructure);
- Needs of the republics in connection with the Union's interests.

The idea was to locate the lands based on the above criteria that would then receive a proportional share of water based on the area, crop pattern and other features. This is how the water allocation criteria tied to the irrigated area started to develop.

The irrigated area in the Valley in 1970 was 1058 thousand ha [S1:42], 720.9 thousand ha (68%) of which was in the Uzbek part [44]. The data in Table S3 show, there was a significant decrease in the number and scope of the shared infrastructure constructed. The new infrastructure was added due to the construction of the canals in early 1970s linked to the Dustlik pump-station which itself had been constructed in 1969. This means that almost no irrigation infrastructure (except the Jiyda canal in 1974 with the capacity to irrigate only 905 ha) was agreed between the riparians on the STTs in this period. Three other projects were the dams with flood control function. The focus shifted from the smaller infrastructure (Table S3) to the implementation measures of the larger infrastructure (Table 2). While a number of projects were completed in the 1970s, the LSKR Canal and Sokh Reservoir for upstream expansion had long delays. The Kyrgyz SSR referred to the agreements reached with the Uzbek SSR on the Andijan Reservoir as an example to persuade Moscow in providing more expansion rights [S1:47], however, Moscow dismissed such requests. Perhaps, the dismissal put the Kyrgyz SSR in the position to raise numerous claims both regarding the irrigation expansion and pasture use unlike in the previous periods. The Kyrgyz SSR had a number of unilateral projects with the potential to irrigate an additional 137,260 ha prepared for implementation within the Ferghana Valley with 66,260 ha being directly connected to shared water resources, *i.e.*, Kayrakkum Reservoir, Khodja-Bakirgan STT, Sokh STT, RSKR Canal, LSKR Canal, and Aravansai STT [S1:58]. In 1974, the Kyrgyz SSR requested Moscow to return the pasturelands used by the other republics within the territory of the Kyrgyz SSR [S1:59].

While there is evidence of monetary (Andijan Reservoir, Karkidon Reservoir) and non-monetary compensation (several cases of land compensation), the Kyrgyz SSR also requested the Uzbek SSR to be connected to gas pipelines as a subsidy (0.5 BCM annually), documenting the first explicit quantitative expression of issue linkages outside the water sector during negotiations [S1:60]. The downstream Uzbek SSR as well as the Kazakh SSR, unlike the Kyrgyz SSR, was to bear the environmental costs as a result of massive expansion. A rapid drop in the level of the Aral Sea and a sharp increase in salinization was expected [S1:42]. There was an estimated 9000-ton loss in fishery from the Aral Sea annually. The impact and the need for diversion of Siberian rivers to the basin was highlighted on the highest level [S1:40], with first design works to be completed in 1971–1975. However, there is no evidence that any design documentation was prepared by that time.

4.4. 1980s: Attempts to Clarify and Solve Conflicting Issues

By 1980, most of the larger infrastructure had been completed and there was a need for new sharing arrangements taking into account all the changes. The following four significant developments were found which shaped the new period of benefit sharing in the 1980s: (1) Increased complexity of issue linkages; (2) Amplified autonomy in decision making and negotiation; (3) Further expansion and basin closure; and (4) Increased cooperation and lost tracks of linked issues previously.

First, the complexity of issue linkages increased to its maximum: while the newer versions of the Schemes connected the infrastructure and developments in the entire Syr Darya Basin in more detail, a new Protocol from 1980 [S1:64] connected all of the STTs in the Ferghana Valley as one package. In addition to the linkages between and across the basins, the non-monetary compensation in the form of land transfer and exchange was discussed and applied more often whereas monetary compensation was no longer observed.

Second, autonomy in decision-making and negotiation amplified further. For example, there is evidence when the Kyrgyz SSR officially contested the decisions approved by Moscow regarding the ways the water shares in the 1980 Protocol were calculated [S1:65]. The design institute argued the main allocation principle was followed [S1:66]. Moscow's purpose to maximize cotton production in the basin had been well established by this period as the Scheme for the basin was in its final stages and discussions were on details rather than on principles. Hence, Moscow gave even more space to the republics for negotiations on the details, as the main purpose with its direct economic benefits for Moscow was more or less secured. On the other hand, the intensifying socio-economic crisis in the USSR during the late 1970s and 1980s [53] was not favorable for Moscow to continue with its active coordination and oversight. In any case, the Kyrgyz SSR kept demanding more water. After the arrangement to share the STTs as one package in 1980 [S1:64], the Kyrgyz SSR, in 7 cases out of 9, including 5 cases where the terms had been implemented, requested to increase its share due to the optimization of water use in the Uzbek part [S1:80].

Third, both the increasing costs to the environment due to basin closure (as the water was utilized to its fullest) as well as the increasing pressure from the Kyrgyz SSR to re-consider allocations implied increased costs for the Uzbek SSR. As of 1 January 1981, the Ferghana Valley had 1227.30 thousand ha of irrigated lands: 255.5 thousand ha (21%) in the Kyrgyz SSR, 124.8 thousand ha (10%) in the Tajik SSR and 847.0 thousand ha (69%) in the Uzbek SSR. The expansion maximum was estimated at 1341.6 thousand ha, which would also change the ratio to 24% (+3%), 10% and 66% (−3%), respectfully [S1:83]. The number of constructed pump-stations in the Uzbek SSR increased rapidly in this period to compensate water to the lands affected by the upstream expansion [54]. Although the lift was unsustainable in the long run due to its high operation and maintenance costs [54], keeping the irrigated lands was important for preventing high social costs at least in a short run and keeping the shares of water tied to the areas of land by the Scheme in a longer run.

Fourth, there was an increased cooperation on the Sokh Reservoir and the Sokh STT, although the construction of infrastructure with shared benefits further slowed down in the 1980s. There were only two shared canals constructed with combined capacity to irrigate 890 ha in the Uzbek part of the Valley (Table S3). The other three projects were flood-controlling dams. In case of the Sokh Reservoir construction, the Uzbek SSR was responsible for the costs, the construction works began and intensified,

but there were still delays to address resettlement issues of the affected population [S1:88]. In case of the Sokh STT, in 1989, the Kyrgyz SSR secured a significant increase in the share from the STT of more than additional 0.2 BCM to irrigate the Burgandy Massive [S1:92]. Expansion in the Burgandy Massive was initially agreed as part of compensation for the lands provided by the Kyrgyz SSR for the Toktogul Reservoir (see the period 1953–1970). The agreement was to irrigate the massive through intakes from the Andijan Reservoir and the Sokh Reservoir. The share from the Andijan Reservoir was 0.2 BCM to be delivered with the LSKR Canal. Although the increased share from the Sokh STT in 1989 exceeded this previously agreed limit, within the same Protocol where this agreement was reached, it was agreed to pursue the projects of the LSKR Canal and the Sokh Reservoir further.

4.5. From 1991 to 2013: Independence and Response to New Old Challenges

From institutional perspective to benefit sharing, the most important distinction of this period is that the republics found themselves between the highest level of autonomy in decision making (sovereignty) by far on one hand, and the highest level of physical (inter-)dependence (shared resources, infrastructure and issue linkages) on the other hand. Irrigation expansion exceeded the planned levels of basin closure, a report from 1991 indicates that the irrigated area in the Ferghana Valley by 1988 was 1382 thousand ha: 290 thousand ha (21%) in Kyrgyzstan, 919 thousand ha (66%) in Uzbekistan, and 173 thousand ha (13%) in Tajikistan [55].

It should be noted, that to date there is abundance of literature on analysis of reforms, problems and opportunities on all possible levels and numerous case studies explaining the situation and possible steps ahead after independence. We do not intend to go through those all but rather maintain our focus on the gap—institutional changes and developments influencing the new period of benefit sharing as well as costs and benefits thereof.

With independence of the states in 1991, the benefit sharing from the existing infrastructure, arrangements and agreements did not stop. In fact, the 1992 Almaty Agreement confirmed the will of all five Central Asian states to adhere to the existing pattern and principles as well as acting regulations of water allocation from interstate resources [S2:1]. This was reinforced within other agreements and declarations later (Table S2). However, implementation of these agreements in a longer run faced a number of challenges.

First, financial difficulties: With problems on how to restore economic and social stability, while the infrastructure built during the Soviet Union was getting outdated and in need of increased investments, the problem was now how to balance between the required more rational use with less finances and meeting the demand for water which became even more crucial for the national economies than before. With the 1998 Syr Darya Framework agreement [S2:7] focusing on the releases from the Toktogul Reservoir, Kyrgyzstan managed to successfully agree with Kazakhstan and Uzbekistan on the compensation mechanisms, which linked water releases with hydropower and fossil fuels between the countries. Tajikistan joined the agreement in 1999. However, due to implementation problems, the Framework Agreement was not renewed after its first five years cycle [29].

Second, although environmental protection received more attention on the regional level agreements (Table S2), implementation of those did not reflect much in the analyzed lower level documents (Table S1), where economic benefits remained dominant. Most of the cooperation on the meso level was

mainly related to maintenance issues—to reconstruct, renovate existing reservoirs (Andijan Reservoir, Papan Reservoir), irrigation and drainage networks. Additional difficulties were observed due to the lengthy clearance processes for crossing the national borders often resulting in delays or indefinite halt of planned maintenance activities. After independence, three shared transboundary projects were constructed (Table S3). While one of them is on the existing canal (Madaniyat-2 pump-station) the other two are flood control infrastructure, hence, all was constructed only to support the existing infrastructure.

Third, no specific interstate organization or framework has been created with focus on managing the shared STTs and their infrastructure. Thus, for the actors on the lower levels in the Ferghana Valley, the institutional arrangement was that the sides were supposed to continue their relationship based on the previous agreements and practice. This implies that there are the following agreements/institutional arrangements in place.

- From transboundary perspective, the latest agreement in place was the 1980 Protocol [S1:64]. However, already during the Soviet period, the sides had disagreements on a number of the agreed terms within the Protocol as described in the analysis of the previous period. A Report from the Kyrgyz side in 2012 [S1:183] mentions the 1989 Protocol [S1:92] as an agreement in place for the Sokh STT. A Report from the Uzbek side of the same year [S1:184] informs that in 2001 an oral agreement was reached to share 3 STTs on a 50/50 basis. However, it is not evident whether it was a one-time agreement to address the drought year. The sides address issues on an ad hoc basis; they exchange requests in case of emergencies such as floods and for annual agreement of decadal allocation from the shared water resources. In addition, with lost linkages behind the LSKR Canal and the Sokh Reservoir, these two continue to be a topic of complaints.
- From a meso level perspective, Uzbekistan has partly shifted from water management according to administrative boundaries (provinces and districts) towards management based on hydrographic/hydrological boundaries of basins and irrigation systems. This was done on the main canals of the Valley (BFC, BAC, SFC). However, the other canals and STTs are left with the WMDs of the provinces [56]. In Kyrgyzstan, in addition to the shift to basin principle, as it was mentioned, Osh province was reorganized into three provinces while the process of restructuring water management in Tajikistan is still in progress [31].

As an outcome of the above challenges and mismatch of institutional arrangements, the incentives of the countries increased to secure more water within their national boundaries, especially since the 1998 Framework Agreement was no longer implemented [29]. With operational change of the Toktogul Reservoir by Kyrgyzstan to meet its energy demand, mid and downstream countries had to find pragmatic solutions increasing internal storage capacities in Uzbekistan and Kazakhstan, re-arranging agreements on certain parts of the Valley as in case of the Isfayramsai, Shakhimardansai and Sokh STTs between Kyrgyzstan and Uzbekistan or the Khodja-Bakirgan STT between Kyrgyzstan and Tajikistan, or attempting to be independent from transboundary infrastructure as the case of Tajikistan on the BFC [29,57].

5. Discussion

Going back to the discussions on water-energy-food nexus, it seems that benefit sharing, as a positive and result-oriented negotiating approach, could be useful to bring about the needed changes and

transition, specifically in managing shared waters. It could serve as a much-needed instrument for what Hoff [12] describes as "stimulating development through economic incentives" (p.37). The historical and institutional analysis, as provided here, seems to offer practical lessons for reconciliation of long-term and global objectives (such as ecosystem stewardship and equity goals) with shorter-term economic benefits, identified as one of the main challenges in the nexus debate [12]. Further, the case study also shows how the isolated focus (e.g., on the Toktogul Reservoir and larger rivers) might have reduced the system efficiency in the long run [12]. Overall, it seems that nexus, which thus far has largely lacked the historical perspective and has not fully viewed management decisions (whether on water, energy, food or their inter-linkages) as a process, could almost entirely borrow the presented analytical approach for assessing evolving institutional settings shaping the scope and effect of the management decisions.

Carrying on with more specific case study findings and looking particularly from benefit sharing point of view, it becomes evident that from one period to the other the benefit sharing increased and incorporated more benefits to the both riparian states (Table 3). Notably, if to follow the typology [4] (Type 1—Environmental; Type 2—Economic; Type 3—Political; and Type 4—Catalytic benefits), the Type 2 benefits remained dominant throughout the entire analyzed period (one should note that here the costs and benefits are deliberately not provided in any explicit way; it is questionable whether issues with this level of complexity and over such long period of time would allow quantifying costs and benefits with any accuracy at all). This highlights the concerns for sustainability of water resources and ecosystems, also discussed in the nexus literature where water is seen as a source or at least as a central factor of economic growth [12,13].

Overall, taking a historical/dynamic or comparative approach highlights that there is a clear gap of how to show differences, particularly since most of the agreements are within Type 2. In addition to the direct costs of benefit sharing development or arrangement (such as construction costs), the analysis pointed to four other possible concerns in the long run, which we term as indirect costs of benefit sharing. In turn, looking at the nature of the lessons on long-term costs, one can state these costs do not necessarily have to limit to benefit sharing, but could be similarly taken into account in the discussions of the nexus approach [12,13].

5.1. Costs Related to Equity of Sharing

Here we are proposing to include "equity" within these particular types/categories so that it would be possible to highlight an increase, stagnation or decrease of these particular types. It could cover the concern pointed out by Tarlock and Wouters [26] regarding transboundary (horizontal) equity in allocation of benefits and it might work well with the social concern of Hensengerth *et al*. [11], which addresses the equity of development vertically. It supports findings of the study by Dombrowsky *et al*. [27] specifically focusing on this aspect of benefit sharing.

Table 3. Summary of the periods.

Periods		Benefits	Benefit Sharing	Mechanisms	Institutions Established
From 1917 to 1953	Types 2 and 4	Increased through boost in smaller infrastructure, pasture exchange	Existed only technically (not voluntarily), founded the shared infrastructure	Central government	Republican borders, property rights on land and infrastructure (Level 2 institutions)
From 1953 to 1970	Type 2	Increased through boost in larger infrastructure, pasture exchange	Emerged with the initiation of larger shared projects, autonomous bilateral negotiation, specific shares of each republics	Monetary and non-monetary compensation, issue linkages within and outside (pastures) water sector, across basins (Nurek Reservoir)	Autonomous negotiations, irrevocable commitments (Toktogul, Andijan and other projects) for revocable ones (Sokh Reservoir, LSKR Canal)
1970s	Type 2	Increased through basin scheme development to use the basin resources to their fullest	Existed and challenged by further autonomy of the republics, increased claims (counter-hegemony) of the Kyrgyz SSR	Monetary and non-monetary compensation, issue linkages within and outside (pastures, gas pipelines) water sector	Proportional water allocation tied to irrigated areas (Level 3 institutions), competition for expansion
From 1980 to 1991	Type 2	Increased through basin closure, rise in pump-stations	Strengthened by further autonomy and official disputation of the Moscow's decisions	Non-monetary compensation, issue linkages within (linking all STTs together) and outside water sector	Governance institutions (Level 3 institutions): managing through sub-basin allocations
From 1991 to 2013	Types 2 and 1	Partly maintained through operation and maintenance of existing infrastructure, enhancement of flood control	Encouraged and tested on regional level but failed (1998 Framework Agreement), practiced on meso level (linked infrastructure and financial incentives), being replaced by national solutions	Issue linkages within and outside water sector (framework of compensations linking water releases, hydropower generation and fossil fuels)	Level 1 (traditions, customs, norms) and Level 2 institutions (above) carried over, Level 3 partly valid, Level 4 (allocative and resource efficiency) attempted by national reforms

The case study brought forward that for the transboundary infrastructure within the Ferghana Valley, property rights and therefore long term sustainability of operation and maintenance of infrastructure are key. Furthermore, while the benefits generated through the infrastructure were shared, the obligation (costs) of operating and maintaining the infrastructure were and are still (except occasionally) not shared. This point highlights the additional need for clearly emphasizing not only benefits but also costs. Looking only at the sharing of benefits might show, that benefit sharing is not equitable.

Besides, in cases when the decisions on forced labor were made solely for the purpose of constructing and operating the infrastructure (1917–1953) internalization of these costs would change the ratio of costs and benefits. Another example, increased unilateral ambitions of the Kyrgyz SSR starting in 1970s emerged because it appears that the Kyrgyz SSR was unsatisfied with the equity of sharing due to the delayed and non-implemented projects. At the same time, the Kyrgyz SSR often argued that the Uzbek SSR increased its water supply levels through unilateral optimization works and therefore requested to re-consider shares to achieve proportional supply levels. This seems to have created a strong disincentive for increasing efficiency as well as incentives for misrepresenting data. In general, such an approach, penalizing a good manager, seems to be a result of serious mismatch between the allocation criteria and improving efficiency.

In addition, looking at Williamson's concept [3], it appears that although there have been tremendous changes regarding the water scarcity situation and the external environment (financial overflow 1960s and 1970s, withdrawal of Moscow and basin closure in the 1980s, independence and financial collapse in 1990), which have triggered adaptation in negotiations and changes of water agreements, so far these changes have not altered the official property rights situation. Besides, the region presents a possibly unique, or at least, very rare case of property rights where a country's infrastructure is located beyond its national boundaries. Further studies are necessary to clearly determine in which case property rights and therefore the obligation to operate and maintain have been altered and the consequences thereof.

5.2. Costs to the Environment

Environmental concern highlighted in the literature [11,26] proved to be absolutely valid throughout the analyzed periods. Given the scales of the developments, integration of "the costs to the water resources" (or "negative benefits to the river") would likely reduce the net economic benefits (Type 2). Even though there are a number of intergovernmental agreements after independence on a national level calling for cooperation in the area of environment and rational use of natural resources the data indicate that the parties focusing on benefits (irrigation expansion) on lower levels have only occasionally considered rising water tables where in fact the focus was on potential economic damage. Institutionalization of a water allocation principle that did not prioritize environmental flow appears to be the main factor in this respect.

5.3. Transaction Costs and Risks of Losing Water Control

Development of uneconomic lift irrigation to secure benefits from water sharing arrangements showed how focusing on benefits might lead to higher costs in the long run especially in a case of multiple interconnected issue linkages.

Similarly, the analysis showed that although there was a clear issue linkage in the beginning (regarding LSKR Canal and the Sokh Reservoir), the two uncompleted infrastructures appeared in

different contexts. Furthermore, today's cooperation appears to be based on a tit-for-tat approach because of the multiple integrated infrastructures. Hence, there is a dynamic of issue linkages within the context of Ferghana Valley. Therefore the original issue linkages (documented in agreements) appear to be in constant flux and utilized as bargaining positions whenever necessary.

Because of the interdependence on transboundary infrastructure cooperation appears to be the most viable option taking a more holistic approach for all infrastructure. It is a likely reason why many projects in the Valley with isolated focus did not succeed as expected. Bigger donors such as the World Bank, Asian Development Bank and United States Agency for International Development focused on the larger rivers without going into details of the lower level inter-dependencies [47,58]. The initiatives of the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) on the Isfara and Khodja-Bakirgan STTs focused on signing bi-lateral agreements, which led to exclusion of Uzbekistan from the Isfara STT [47,51,58]. The projects of the Swiss Agency for Development and Cooperation (SDC) on the Shakhimardansai and Khodja-Bakirgan STTs, although focused on bottom up cooperation, basically did not succeed due to a weak link up with higher frameworks [47,58].

One should note that all that transboundary tributaries, where the previous agreement was challenged, are within the same 'newly created' administrative unit (Batken Province), similarly, the small reservoir (Kasansai), which appears to have the most problems regarding cooperation [30] is also located in a "newly created" administrative unit (Jalalabad Province). This puts into question whether decentralization as practiced by Kyrgyzstan has decreased cooperation, since it decreased the possibility of issue linkage. Similarly, the water reforms in Uzbekistan (the partly implemented hydrographization [56]) might have negative effects on cooperation, since it reduced the bargaining positions of the former players (Andijan and Ferghana Provinces). In this respect, it might be important to highlight that the practice of honoring past agreements (national level) might be put into question, particularly if lower levels are tasked with the implementation and these lower levels cease to exist or have reduced bargaining power. Having stated this, one could also question whether the national level in Kyrgyzstan has control over the meso level administrative units [59].

5.4. Costs Resulting from Misuse of Issue Linkages

The issue linkages, on one hand, have helped to achieve cooperation and conclude multiple agreements. On the other hand, it created a number of linkages between asymmetric issues. The Toktogul was linked during the Andijan Reservoir negotiations to compensate the lands under the Toktogul by expansion rights in the Burgandy Massive. The Burgandy Massive was linked to the LSKR Canal and Sokh Reservoir. While the Toktogul and Andijan Reservoirs became irrevocable commitments the LSKR Canal and Sokh Reservoir were revoked and never completed. The significant increase in the share from the Sokh STT, which boosted irrigation in the Burgandy Massive for Kyrgyzstan, did not stop them from continuing or even reconsidering the claims on the LSKR Canal and Sokh Reservoir. Hence, both the scope and symmetry of issues to be linked are important to be able to follow through and implement the agreements in a longer period.

Similarly, what seems to be not explored enough from benefit sharing perspective is the focus beyond the river, which entails the brokering (including financial incentives and issue linkages) as well as

arbitration role of third parties, in this case of Moscow. As the analysis suggests, the interests and influence of third parties might completely re-design the structure of both benefits and sharing.

6. Conclusions

Countries need dialogue and coordinated actions to address dynamic challenges and to shift towards more holistic views in managing shared water resources. While the water-energy-food nexus is the most recent way to promote more holistic views, it seems to largely lack both historical and institutional perspectives: this study has emphasized the importance of such perspectives. Our research indicated evolution and implications of institutional settings for shaping management decisions and revealed multiple factors limiting as well as enabling cooperation in a highly complex environment. The focus on benefit sharing as an approach demonstrated that new arrangements and developments with shared benefits and mutual gains provide a good platform for the needed dialogue. Yet, the research findings also brought to attention possible indirect costs associated with benefit sharing in the long run, which might have been overlooked in the literature. It seems incorporations of these costs could contribute to making cooperation and dialogue more constructive and informed and therefore new arrangements more stable.

The case study has identified five different periods of development in the relationship related to management of the shared water resources in the Ferghana Valley between 1917 till present between Kyrgyzstan and Uzbekistan. A particular focus has been placed on what can be learned from benefit sharing perspective. From the earlier Soviet period under the Stalin's strong regime when the property rights on land and more importantly on shared infrastructure were established, the analysis showed that the institutional transformation between the republics took place already in the period from 1953 to 1970 in time of heroic engineering projects targeting cotton independence of the USSR. However contradictory, already then the republics got to negotiate whether to construct, what to construct and how to share benefits. A very strong top down administration started to transform into a bottom up hierarchy. In the 1970s, the republics gained even more autonomy when Kyrgyzstan claimed its major expansion and return of pasturelands. Ambitious plans to boost the water supply resulted in increased expectations leading to new water shortages. Later in the 1980s, the official disputation of the decisions approved by Moscow became acceptable; Uzbekistan had to compensate the loss caused by Kyrgyz expansion in the previous decade. Finally, the period of independence continued with what was left from the Soviets but with significantly less financing, which led to both some cooperative and some national solutions.

Along the entire analyzed period, institutions that are still, at least partly, valid were established. In addition to the property rights, proportional allocation principle is still referred as the central principle for allocation of water. The principle is biased to the criteria of the time it was developed. That is partly why the governance institutions do not function effectively. In addition, the principle itself is contradictory to increasing efficiency, as it requires reconsideration of the allocation with any disproportional change in water supply, which in turn contradicts with the closure of the basin and fixed shares. Without taking into consideration these concerns, benefit sharing might become prone to inequity both horizontally and vertically, failure to internalize environmental costs, loss of water control due to the scope of issue linkages as well as vulnerability in implementation due to asymmetrical commitments.

Separation of the issues on border crossing due to the security concerns from the water and land management sectors is indeed one of the constraints for successful cooperation because of the nature of

property rights for infrastructure located beyond the national boundaries. In this regard, a similar case of the Tuyamuyun Reservoir with the pump-stations on the Amu Darya River shared by Turkmenistan and Uzbekistan could be studied for possible lessons. An additional framework agreement on passing the borders at least for operations and maintenance purposes would reduce the *ad hoc* nature of the issues and bring more stability to the existing cooperation. The case of the Chu and Talas Rivers seems to be relevant for further comparative studies from issue linkages perspective as well as to learn more successful agreements of maintenance sharing.

Overall, the situation is extremely complex: geographically, infrastructure-wise as well as institutionally. However, it is necessary for the complexity to be taken into account in the development of appropriate policy. Simplification of issues might have actually led to the decline in cooperation, since the later arrangements in the Syr Darya, as well as Amu Darya and larger Aral Sea basins, were mainly brokered by donors, which did not engage comprehensively with the big picture. One lesson from the historical complexity is the desire for each state to have independence in water management—with each nation focusing on its own water resources. However, the possible gains from further dialogue and cooperation are clear.

Supplementary Materials

Supplementary materials can be found at http://www.mdpi.com/2073-4441/7/6/2728/s1.

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Author Contributions

Ilkhom Soliev developed the initial and final versions of the framework, analyzed the data, organized the systematic discussion of the costs and led the drafting process of the study incorporating the contributions from co-authors as well as from the reviewers and editors; Kai Wegerich proposed the initial idea of testing the approach in case of the Ferghana Valley, contributed by interim editing of the paper, drafting the initial version of the discussion section, structure of the study and raising critical

questions on the approach; Jusipbek Kazbekov contributed by providing his expertise and insights on the study area and historical-institutional arrangements as well as clarifications in understanding complications and connections of the collected data, facilitated the development of the updated map.

Conflicts of Interest

The authors declare no conflict of interest.

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Supplementary Materials

Table S1. List of studied documents relevant to the benefit sharing in the water and land resources development in the Ferghana Valley.

Chronological order of the document	Document [1]	NO.	Date	Relevance to (Present) Benefit Sharing [2]	Type [4] of Benefits [3]
1.	Decree on Land adopted by the 2nd All-Russian Congress of the Soviets of Deputies of Workers, Soldiers and Peasants		27 October 1917	Property rights for land, borders	2, 4
2.	Resolution of the Council of People's Commissars of the Union of Soviet Socialistic Republics (USSR) on provision of the pastures for the livestock of the Ferghana group of districts of the Uzbek Soviet Socialistic Republic (SSR). Osh province Water Management Department (WMD)	1313	27 June 1935	Pasture exchange, borders	2, 4
3.	Resolution of the Council of People's Commissars of the Kyrgyz SSR on provision of kolkhozes of the Uzbek SSR in the Ferghana Valley with pastures in the Kyrgyz SSR	1337	19 September 1939	Pasture exchange, borders	2, 4
4.	Resolution of the Council of Ministers of the USSR on consolidation of the pastures under State Custody for the kolkhozes of the Uzbek, Kazakh, Kyrgyz and Tajik SSRs and their reclamation	1509	09 July 1946	Pasture exchange, borders	2, 4
5.	Order of the Ministry of Land Reclamation of the USSR on consolidation of the pastures under State Custody for the kolkhozes of the Uzbek, Kazakh, Kyrgyz and Tajik SSRs and their reclamation	426	22 July 1946	Pasture exchange, borders	2, 4
6.	Law of the USSR on agricultural tax		08 August 1953	n/a	n/a
7.	Resolution of the Council of Ministers of the USSR on unified state accounting of lands	2529	31 December 1954	n/a	n/a
8.	Order of the Ministry of Agriculture of the USSR on consolidation of pastures under the State Land Fund for the kolkhozes of the Uzbek, Kazakh, Kyrgyz, Tajik and Turkmen SSRs	623	31 December 1955	Pasture exchange, borders	2, 4
9.	Resolution of the Council of Ministers of the USSR on the order of design and construction of reservoirs and hydropower stations	1251	07 September 1956	Increased autonomy in decision making	2, 3
10.	Decree of the Presidium of the Supreme Council of the USSR on liability of non-fulfillment of plans		24 April 1958	n/a	n/a
11.	Resolution of the Council of Ministers of the Kyrgyz SSR on redistribution of the lands of the sovkhoz "Chatkal" to kolkhozes and sovkhozes of the Uzbek SSR, Kazakh SSR, as well as Lenin and Kirov districts of the Kyrgyz SSR	201	17 April 1959	Land exchange, borders	2, 4
12.	Protocol of the Meeting of the representatives of the Uzbek and Kyrgyz SSRs on water shares on Aravansai and Akburasai systems		25 May 1961	Water sharing	2
13.	Protocol of the Inter-republican and Inter-province Meeting on water allocation issues of the Isfayramsai and Shakhimardansai STTs		21 July 1961	Water sharing	2
14.	Protocol of the Inter-republican Meeting of the representatives of the Kyrgyz and Uzbek SSRs on water allocation issues of the Karadarya river system		18 July 1962	Water sharing	2

Table S1. *Cont.*

Chronological order of the document	Document [1]	NO.	Date	Relevance to (Present) Benefit Sharing [2]	Type [4] of Benefits [3]
15.	Internal Note on the issue of the Kampyr-Ravat (Andijan) reservoir for the flow regulation of the Karadarya river		24 July 1962	Water sharing	2
16.	Letter for approval from Uzbek SSR to Kyrgyz SSR for construction of the Kampyr-Ravat (Andijan) reservoir		02 August 1962	Increased water supply, water sharing	2
17.	Resolution on the proposal of the Central Committee of the Communistic Party, Council of Ministers and Supreme Council of the Uzbek SSR on the construction of the Kampyr-Ravat (Andijan) reservoir in Uzgen district of the Kyrgyz SSR	45/8-B	13 September 1962	Increased water supply, water sharing	2
18.	Letter to the Central Committee of the Communistic Party, Council of Ministers of the Uzbek SSR	6/21	26 September 1962	Increased water supply, water sharing	2
19.	Letter to the Central Committee of the Communistic Party, Council of Ministers of the Kyrgyz SSR	252-33	08 January 1963	Increased water supply, water sharing	2
20.	Order of the Council of Ministers of the USSR on the approval of the project document of the construction of the Kampyr-Ravat (Andijan) reservoir	511-P	15 March 1963	Increased water supply, water sharing	2
21.	Protocol of the Inter-republican Meeting on the construction of the second stage of the Kirkidon (Karkidon) reservoir		20 February 1964	Increased water supply, water sharing	2
22.	Conclusion of the Osh province WMD on the scheme of use of the water resources of the Karadarya river basin taking into account the Kampyr-Ravat (Andijan) reservoir		18 August 1964	Increased water supply, water sharing	2
23.	Protocol of the Meeting under the Director of the State Design Institute on Land use "Uzgiprozem"		12 February 1965	Increased water supply, water sharing	2
24.	Decision on the withdrawal of the lands from the land users in the Uzgen and Karasu districts for the construction needs of the Kampyr-Ravat (Andijan) reservoir	285	11 May 1965	Increased water supply, water sharing	2
25.	Internal Note of the Council of Deputies of Osh province of the Kyrgyz SSR on the Decision #285 11 May 1965 on the withdrawal of the lands from the land users in the Uzgen and Karasu districts for the construction needs of the Kampyr-Ravat (Andijan) reservoir		11 May 1965	Increased water supply, water sharing	2
26.	Proposition on additional measures to mitigate low water conditions in the Syr Darya and Karadarya river basins		18 June 1965	Water sharing	2
27.	Protocol of the Meeting of the representatives of the Ministries of water management of the Uzbek and Kyrgyz SSRs, Design institutes "Sredazgiprovodhlopok" and "Kyrgyzgiprovodhoz" on use of water resources of the Kara-Darya river with Andijan/Kampyr-Ravat reservoir		23 September 1965	Increased water supply, water sharing	2

Table S1. *Cont.*

Chronological order of the document	Document [1]	NO.	Date	Relevance to (Present) Benefit Sharing [2]	Type [4] of Benefits [3]
28.	Resolution of the Council of Ministers of the Kyrgyz SSR on the allocation of the lands for the construction of Kampyr-Ravat (Andijan) reservoir	475	22 October 1965	Increased water supply, water sharing	2
29.	Protocol of the Meeting of the representatives of the Ministries of Agriculture of the Uzbek and Kyrgyz SSRs, Ministries of Melioration and Water Resources of the Uzbek and Kyrgyz SSRs with participation of representatives of the State Construction department of the Kyrgyz SSR, institutes "Sredazgiprovodhlopok", Osh Oblvodkhoz on some issues related to the construction of the Andijan/Kampyr-Ravat reservoir		12 November 1965	Increased water supply, water sharing	2
30.	Resolution of the Councils of Ministers of the Kyrgyz and Uzbek SSRs on some issues related to the construction of the Andijan/Kampyr-Ravat reservoir	559/656	11 December 1965	Increased water supply, water sharing	2
31.	Resolution of the Council of Ministers of the Uzbek SSR on the allocation of the lands in connection with the construction of the Andijan/Kampyr-Ravat reservoir	659	15 December 1965	Increased water supply, water sharing	2
32.	Protocol of the Inter-republican Meeting on agreement on the Terms of Reference of the Left-shore canal with water intake from the upstream of the Uch-Kurgan Hydropower Station			Increased water supply, water sharing	2
33.	Protocol of the Meeting of the representatives of the Ministries of Melioration and Water Resources of the Uzbek and Kyrgyz SSRs and the institutes Uzgiprovodkhoz and Kyrgyzgiprovodkhoz		12 July 1968	Increased water supply, water sharing	2
34.	Law of the USSR on the fundamentals of land legislation		13 December 1968	Increased autonomy in dispute resolution	2, 3
35.	Protocol of the Commission on resolving the land-management issues between Osh province of the Kyrgyz SSR and Andijan province of the Uzbek SSR		07 December 1969	Water sharing, land exchange	2
36.	Decision of the Executive Committee of the Council of Deputies of Osh province on construction of the Left-shore Naryn Canal and pump station of the Uzbek SSR on the territory of Lenin district of Osh province (Kyrgyz SSR) and partial implementation of the 1958 decisions of the Parity Inter-republican Commission of the Uzbek and Kyrgyz SSRs		08 December 1969	Increased water supply, water sharing	2
37.	Resolution of the Council of Ministers of the Kyrgyz SSR on the allotment of the lands in connection with resolving land-management issues between Osh province of the Kyrgyz SSR and Andijan province of the Uzbek SSR		08 December 1969	Land exchange, increased water supply, water sharing	2
38.	Letter to the Secretary of the Communistic Party of the Uzbek SSR on the compensation for the expenses related to the construction of the Andijan/Kampyr-Ravat reservoir	110/10-c	01 April 1970	Land exchange, increased water supply, water sharing	2

Table S1. *Cont.*

Chronological order of the document	Document [1]	NO.	Date	Relevance to (Present) Benefit Sharing [2]	Type [4] of Benefits [3]
39.	Letter to the Secretary of the Communistic Party of the Kyrgyz SSR on the compensation for the expenses related to the construction of the Andijan/Kampyr-Ravat reservoir	1-204c	1970	Land exchange, increased water supply, water sharing	2
40.	Order of the Ministry of Agriculture of the USSR and the Ministry of Water resources of the USSR on the land reclamation development perspectives in 1971-1985, regulation and re-allocation of the runoff of rivers. Osh province WMD	229/186	17 August 1970	Water and land resources development across the region, priorities	2, 3, 4
41.	Law of the USSR on the fundamentals of water legislation		10 December 1970	Formalizing Schemes—Basin approach	2, 3, 4
42.	Protocol of the Meeting of the scientific-technical council of the Ministry of Water resources of the USSR held in Moscow		22-23 February 1972	Development of Scheme for the Syr Darya	2, 3, 4
43.	Protocol of the Meeting of the Inter-republican Commission on regulation of the land-water management issues between the Uzbek SSR and the Kyrgyz SSR		08 May 1972	Water sharing, sharing and exchange of responsibilities, property rights of infrastructure	2, 3, 4
44.	Letter from the design institute Sredazgiprovodkhlopok to the Council of Ministers of the Kyrgyz SSR on the Corrective Note to the Scheme of complex use of water resources of the Syr Darya basin. Osh province WMD	52-1691	09 August 1972	Development of Scheme for the Syr Darya	2, 3, 4
45.	Letter from the Council of Ministers of the Kyrgyz SSR to the Gosplan of the USSR, State Experts Commission (SEC) and institute Sredazgiprovokhlopok. Osh province WMD	11-8/58	05 January 1973	Development of Scheme for the Syr Darya	2, 3, 4
46.	Resolution of the SEC of State Planning Committee (Gosplan) USSR on expertise of the Scheme of the complex use of the water resources of the Syr Darya river. Osh province WMD	2	07 February 1973	Development of Scheme for the Syr Darya	2, 3, 4
47.	Letter from the Kyrgyz SSR to the Gosplan of the USSR, SEC and design institute Sredazgiprovodkhlopok	11-8/58	07 May 1973	Development of Scheme for the Syr Darya	2, 3, 4
48.	Report of the Minister of Water resources of the Kyrgyz SSR to the Government of the Kyrgyz SSR on the Resolution #2 (7/02/1973) of the SEC Gosplan USSR. Osh province WMD		1973	Setting national priorities	2
49.	Protocol of the Inter-republican Meeting on regulation of land-water management issues between Uzbek SSR and Kyrgyz SSR	325-p	07 June 1973	Water and pasture sharing, increased water supply, sharing responsibilities	2, 3, 4
50.	Notes of the Ferghana province Executive Committee on the Protocol of the Inter-republican Meeting on regulation land-water management issues between the Uzbek SSR and Kyrgyz SSR		07 June 1973	Pasture sharing, increased autonomy	2, 3

Table S1. *Cont.*

Chronological order of the document	Document [1]	NO.	Date	Relevance to (Present) Benefit Sharing [2]	Type [4] of Benefits [3]
51.	Letter of the Council of Ministers of the Uzbek SSR on the draft of the joint Resolution on approval of the Protocol of the inter-republican meeting on regulating the land-water management issues between the Kyrgyz SSR and the Uzbek SSR	10/12-19	14 June 1973	Water sharing, increased water supply, sharing responsibilities, property rights of infrastructure	2, 3
52.	Internal Note on the draft of the joint Resolution of the Council of Ministers of the Uzbek SSR and the Council of Ministers of the Kyrgyz SSR "On the land-water management issues between the Kyrgyz SSR and the Uzbek SSR"	15-1/4	27 June 1973	Water and pasture sharing, increased water supply, sharing responsibilities	2, 3, 4
53.	Questions on land management from the Kyrgyz SSR to the Uzbek SSR		1974	Land exchange, borders	2, 3
54.	Response Letter to the Letter from the Central Committee of the Communistic Party of Uzbekistan and Council of Ministers of Uzbek SSR	37/344	1974	Land exchange, borders	2, 3
55.	Reference Certificate of the Osh province WMD on Inter-republican water allocation issues between the Kyrgyz SSR and Uzbek SSR		1974	Water sharing, increased water supply, sharing responsibilities	2
56.	Reference Certificate of the Osh province WMD on provision of land for use by the Uzbek SSR in the territory of the Kyrgyz SSR		1974	Land exchange, issue linkages with other sectors	2
57.	Reference Certificate of the Osh province WMD on the issues of Inter-republican land use between Osh province of the Kyrgyz SSR and provinces of the Uzbek, Tajik and Kazakh SSRs		1974	Pasture exchange, borders, livestock development	2, 3
58.	Reference Certificate on the highest priority objects of water infrastructure in Osh province of the Kyrgyz SSR		1974	Water sharing, increased water supply, sharing responsibilities	2
59.	Letter from the Kyrgyz SSR to the Minister of Agriculture of the USSR on the issues of Inter-republican land use between Osh province of the Kyrgyz SSR and provinces of the Uzbek, Tajik and Kazakh SSRs		1974	Pasture exchange, borders, livestock development	2, 3
60.	Letter from the Kyrgyz SSR to the Secretary of the Communistic Party of the Uzbek SSR on the land-water management issues between Osh province of the Kyrgyz SSR and Ferghana, Andijan, Namangan provinces of the Uzbek SSR		1974	Land compensation, reconsidering water allocation	2
61.	Report on the results of the Meeting of the representatives of the Uzbek and Kyrgyz SSRs		06 September 1974	Water sharing, land compensation	2
62.	Protocol of the Meeting on inter-seasonal water allocation of the Isfara river among the Tajik, Uzbek and Kyrgyz SSRs		21 November 1974	Water sharing, increased water supply, sharing responsibilities	2
63.	Resolution of the Council of Ministers of the USSR on the order of implementing activities on preparation of the zones of flooding related to the construction of hydropower stations and reservoirs. Osh province WMD	76	02 February 1976	Compensation for the losses	2

Table S1. *Cont.*

Chronological order of the document	Document [1]	NO.	Date	Relevance to (Present) Benefit Sharing [2]	Type [4] of Benefits [3]
64.	Protocol of the Inter-republican allocation of runoff of the small rivers in the Ferghana Valley		10 April 1980	Water sharing, linking all water resources	2
65.	Notes from the Kyrgyz SSR to the Protocol 10/04/1980 on Inter-republican allocation of the runoff of the small rivers of the Ferghana Valley		1980	Increased autonomy in decision making, water sharing, linking all water resources	2
66.	Response Certificate to the Notes made by the Kyrgyz SSR to the Protocol 10/04/1980 on Inter-republican allocation of the runoff of the small rivers of the Ferghana Valley		1980	Increased autonomy in decision making, water sharing, linking all water resources	2
67.	Letter from the Central Committee of the Communistic Party and the Council of Ministers of the Kyrgyz SSR on the unresolved land-water management issues between the Kyrgyz SSR and the Uzbek SSR	133/10-c	16 April 1980	Water sharing, linking water resources	2
68.	Letter from the Central Committee of the Communistic Party and the Council of Ministers of the Uzbek SSR in response to the Letter #133/10-c dd. 16/04/1980 on the land-water issues between the Kyrgyz SSR and the Uzbek SSR	BX-1-454	07 May 1980	Water sharing, linking all water resources	2
69.	Information on allocation of water resources of the small rivers of the Ferghana Valley between the Uzbek SSR and Kyrgyz SSR on irrigation		1980	Water sharing, linking all water resources	2
70.	Theses to the Meeting on inter-republican water allocation between the Kyrgyz SSR and the Uzbek SSR		1980	Water sharing, linking all water resources	2
71.	Agreement on regulation of the issues of water allocation from the small rivers between Uzbek and Kyrgyz Republics through joint consideration of the water management departments of Ferghana and Osh provinces		28 August 1980	Water sharing, linking water resources, sharing responsibilities	2
72.	Decision of the Executive Committee of the Council of Deputies of Osh province on the allocation of the lands for the construction of the Sokh reservoir, complex of industrial and civil buildings for it as well as for the objects being relocated from the flooding zone belonging to the land users of Batken and Frunze districts of Osh province	440	28 August 1980	Water sharing, linking water resources, sharing responsibilities	
73.	Agreement on regulation of the issues of water allocation from the small rivers between Uzbek and Kyrgyz Republics through joint consideration of the water management departments of Andijan and Osh provinces		29 August 1980	Water sharing, linking water resources, sharing responsibilities	
74.	Notes of the Osh province Council to the refined scheme of complex use and protection of water resources in the Syr Darya basin		no date assumed 1980	Further development of Scheme	

Table S1. *Cont.*

Chronological order of the document	Document [1]	NO.	Date	Relevance to (Present) Benefit Sharing [2]	Type [4] of Benefits [3]
75.	Information on the farmlands in the Toktogul district, flooded by the Toktogul reservoir due to the construction of the hydropower station		no date assumed 1980	Water sharing, increased water supply, land compensation	2
76.	Information on the lands of the Kyrgyz SSR given for construction of reservoirs, canals and hydropower stations to other republics		no date assumed 1980	Water sharing, increased water supply, land compensation	2
77.	Information on the lands of Osh province of the Kyrgyz SSR given to the Uzbek, Tajik and Kazakh SSRs for long-term use as pastures		no date assumed 1980	Pasture exchange, land compensation	2
78.	Letter from the Osh province Executive Committee of the Council of Peoples' Deputies to the Ministry of Water resources of the Uzbek SSR and the Ministry of Water resources of the Kyrgyz SSR on water compensation for the non-used share of the Kyrgyz SSR from the Andijan reservoir		no date assumed 1980	Water sharing, increased water supply, water compensation	2
79.	Annotation on allocation of water resources of the rivers of the Ferghana Valley between the Uzbek SSR and Kyrgyz SSR during the vegetation period of 1981 and other unresolved issues		1981	Water sharing, reconsidering shares	2
80.	Reference Certificate on the implementation of the Protocol dd. 10/04/1980 on inter-republican allocation of the runoff of the small rivers of the Ferghana Valley approved by the Deputy Minister of Water resources of the USSR and other inter-republican questions		01 June 1981	Water sharing, linking water resources, sharing responsibilities, reconsidering shares	2
81.	Stage Questions on Water related construction to the Uzbek SSR		01 June 1981	Water sharing, linking water resources, sharing responsibilities, reconsidering shares	2
82.	Protocol of the Meeting on the decadal allocation of the runoff of the Sokh STT, Shakhimardansai STT and Isfayramsai STT between the Uzbek and Kyrgyz SSRs		14 June 1981	Water sharing	2
83.	Corrective Note to the Refined Scheme of the Complex Use and Protection of Syr Darya River Basin 1983. Ministry of Melioration and Water Resources of USSR, detailed in Protocol #413 dd. 29 February 1984, Sredazgiprovodkhlopok (in Russian).		1983	Further development of Scheme	2
84.	Scheduled water intake on filling and releasing the Papan reservoir on the Akburasai STT under 75% water supply		no date	Water sharing	2
85.	Letter from Osh province WMD to Andijan province WMD on the clarification of the lands and water allocation from the Maylisai STT		27 February 1985	Water sharing, reconsidering shares	2

Table S1. *Cont.*

Chronological order of the document	Document [1]	NO.	Date	Relevance to (Present) Benefit Sharing [2]	Type [4] of Benefits [3]
86.	Letter from Andijan province WMD to Osh province WMD on the clarification of the lands and water allocation from the Maylisai STT		15 March 1985	Water sharing, reconsidering shares	2
87.	Report on the design and construction of the Sokh reservoir, Ferghana province WMD		1986	Water sharing, increased water supply	2
88.	Protocol of the Meeting on agreement on the volumes and deadlines for preparation of the documentation on design specification and estimates as well as for construction of the objects by the Ferghanavodstroy of the Uzbek SSR in compensation of the objects in the zone flooding by the Sokh reservoir in the territory of the Kyrgyz SSR		9-12 February 1988	Water sharing, increased water supply, compensation for resettlement	2
89.	Protocol of the Meeting on the process of designing and construction of the objects in the Aygultash settlement (Sokh reservoir) of Batken district of Osh province		1-2 March 1988	Water sharing, increased water supply, compensation for resettlement	2
90.	Protocol of the Meeting of the Technical Council of the Ministry of water resources of the Kyrgyz SSR	1634	30 March 1989	Water sharing, sharing responsibilities	2
91.	Protocol of the Meeting of the Parity Commission of the Uzbek SSR and the Kyrgyz SSR on regulation of the issues between sovkhozes Khushyor of Rishtan district of Ferghana province and Pervomayskiy of Batken district of Osh province		17 June 1989	Water sharing, reconsidering shares	2
92.	Protocol of the Technical Meeting on regulation of the water management issues between the State Committee for water resources of the Uzbek SSR and the Ministry of water resources of the Kyrgyz SSR	3	22 August 1989	Water sharing, reconsidering shares	2
93.	Protocol of the Meeting on the issues related to operations of the Tortgul reservoir on the Isfara STT and water sharing between Kyrgyzstan and Tajikistan. Osh province WMD		16 May 1991	Water sharing, increased water supply reconsidering shares	2
94.	Letter from the Government of Uzbekistan to the Government of Kyrgyzstan on resuming the construction works of the Sokh reservoir	30-5610	08 July 1993	Water sharing, increased water supply, compensation for resettlement	2
95.	Letter from the Kadamjai district Water Management Department (WMD), Kyrgyzstan to the Osh province WMD, Ferghana province WMD, Ministry of Agriculture and Water Resources (MAWR) Kyrgyzstan on increasing water supply from the Isfayramsai, Shakhimardansai Small Transboundary Tributaries (STTs), Andijan reservoir, Left-shore Kampyr-Ravat canal (LSKR)	87	08 June 1995	Water sharing, reconsidering shares	2
96.	Request from the Osh province Governor to the Osh province WMD to draft a letter to the Uzbek side with request to increase the share of Kyrgyzstan on STTs		22 January 1997	Water sharing, reconsidering shares	2

Table S1. *Cont.*

Chronological order of the document	Document [1]	NO.	Date	Relevance to (Present) Benefit Sharing [2]	Type [4] of Benefits [3]
97.	Schedule from the MAWR Kyrgyzstan to the MAWR Uzbekistan, Big Ferghana Canal (BFC) authority on the decadal water allocation of the Karkidon feeder canal	06-166	04 April 1997	Water sharing	2
98.	Letter from the Osh province Basin WMD (BWMD) to the Andijan province WMD, BFC authority on increasing water supply from the Karkidon feeder canal		28 July 1997	Water sharing, reconsidering shares	2
99.	Letter (message) from Aravan district WMD to the Osh province BWMD	26	27 August 1997	Water sharing	2
100.	Letter (message) from the BFC authority to the Osh province BWMD on water shortage and compensation of the BFC, South Ferghana Canal (SFC), Andijan reservoir, Karkidon feeder canal	442	29 August 1997	Water sharing	2
101.	Letter from the Ferghana province WMD to the Osh province BWMD on increasing water supply of the Karkidon feeder canal, Isfayramsai, Shakhimardansai STTs		9 September 1997	Water sharing, issue linkages	2
102.	Report to the head of the Osh province WMD from the field monitor		10 September 1997	Water sharing	2
103.	Letter from the Osh province WMD to the Ferghana province BWMD on increasing water supply of the Karkidon feeder canal		10 September 1997	Water sharing, issue linkages	2
104.	Proposition of the Osh province WMD on reclamation of lands near the border with Tajikistan		1997	Irrigation expansion, borders	2
105.	Letter from the Andijan province WMD to the Osh province administration on crossing the border for Operations and Management (O&M), bridge construction of the Savai canal		1998	O&M, border crossing	2
106.	Letter from the Jalalabad province administration to the Andijan province administration on crossing the border for transportation for flood control dam on the Karadarya		21 September 1999	O&M, border crossing	2
107.	Protocol of the work of the Inter-agency water management commission of Uzbekistan and Kyrgyzstan. Andijan province WMD		19 March 2002	O&M	2
108.	Letter from the Andijan province WMD to the Osh province WMD on the O&M of the Andijan and Papan reservoirs		17 April 2002	O&M	2
109.	Protocol of the work of the Inter-agency water management commission on examining the dam of the Papan reservoir and estimation of the operational costs. Andijan province WMD		19 April 2002	O&M	2
110.	Protocol of the work of the Inter-agency water management commission on examining the impact of the Andijan reservoir on the surrounding lands and the condition of the runoff of the Karadarya and Yassi rivers of Uzgen district upstream the reservoir. Andijan province WMD		03 June 2002	O&M	2
111.	Letter from the Osh province BWMD to the Andijan province WMD on the O&M of the Andijan reservoir		14 July 2002	O&M	2

Table S1. *Cont.*

Chronological order of the document	Document [1]	NO.	Date	Relevance to (Present) Benefit Sharing [2]	Type [4] of Benefits [3]
112.	Letter from the Osh province BWMD to the MAWR Uzbekistan on the O&M of the Papan reservoir		04 September 2002	O&M	2
113.	Letter from the Osh province BWMD to the Kyrgyzstan WMD on flood recovery of the Aravansai STT	01-240	05 September 2002	O&M	2
114.	Letter from the Osh province BWMD to the Andijan province WMD on the O&M of the Andijan and Papan reservoirs		17 March 2003	O&M	2
115.	Letter from the Osh province BWMD to the Andijan province WMD on flood recovery of the RSKR canal	01-161	28 May 2003	O&M	2
116.	Letter from the Osh province BWMD to the Andijan province WMD on the O&M of the Andijan reservoir		11 June 2003	O&M	2
117.	Letter from the Naryn-Karadarya (NK) Basin Irrigation Systems Authority (BISA) to the Jalalabad BWMD on crossing the border for O&M of the Pump-stations		24 February 2004	O&M, border crossing	2
118.	Letter from the NK BISA to the Jalalabad province, Nookent district Burgandy village administration on the O&M of the Nushkan canal, M 1-2 canal		25 February 2004	O&M	2
119.	Schedule from the NK BISA, MAWR Uzbekistan to the Jalalabad BWMD, Kyrgyzstan WMD on the decadal water allocation of the Suzak canal		16 April 2004	Water sharing	2
120.	Schedule from the NK BISA, MAWR Uzbekistan to the Jalalabad BWMD, Kyrgyzstan WMD on the decadal water allocation of the Maylisai STT		16 April 2004	Water sharing	2
121.	Schedule from the NK BISA, MAWR Uzbekistan to the Jalalabad BWMD, Kyrgyzstan WMD on the decadal water allocation of the RSKR canal		16 April 2004	Water sharing	2
122.	Protocol on joint examination of operations and maintenance works of the Savai canal		25 June 2004	O&M	2
123.	Letter from the NK BISA to the Jalalabad province, Nookent district administration, Jalalabad BWMD on the long-term use of lands by Uzbekistan and distribution by Kyrgyzstan of the lands in Jalalabad province		13 August 2004	Land use clarification	2
124.	Letter from the Karadarya-Maylisai (KM) Irrigation Systems Authority (ISA) to the Regional Prosecutor of Osh, Jalalabad, Batken on the O&M of the Left-shore Naryn canal	104	24 November 2004	O&M	2
125.	Letter from the KM ISA to the Jalalabad province Interior affairs department on the O&M of the Left-shore Naryn canal		24 November 2004	O&M	2
126.	Schedule from the NK BISA, MAWR Uzbekistan to the Jalalabad BWMD, Kyrgyzstan WMD on the decadal water allocation of the Akburasai STT		2004	Water sharing	2

Table S1. *Cont.*

Chronological order of the document	Document [1]	NO.	Date	Relevance to (Present) Benefit Sharing [2]	Type [4] of Benefits [3]
127.	Schedule from the NK BISA, MAWR Uzbekistan to the Jalalabad BWMD, Kyrgyzstan WMD on the decadal water allocation of the Savai canal		2004	Water sharing	2
128.	Schedule from the NK BISA, MAWR Uzbekistan to the Jalalabad BWMD, Kyrgyzstan WMD on the decadal water allocation of the Aravansai STT		2004	Water sharing	2
129.	Schedule from the NK BISA, MAWR Uzbekistan to the Jalalabad BWMD, Kyrgyzstan WMD on the decadal water allocation of the Savai canal		2004	Water sharing	2
130.	Letter from the Osh province BWMD to the NK BISA on the O&M of the Savai canal		March 2005	O&M	2
131.	Letter from the Osh province BWMD to the Syrdarya-Sokh (SS) BISA on increasing water supply of the Isfayramsai STT		07 April 2005	Water sharing	2
132.	Letter from the Osh province BWMD to the NK BISA on the O&M of the Savai canal		13 May 2005	O&M	2
133.	Letter from the Osh province BWMD to the Kyrgyzstan WMD on flood recovery of the Aravan district	01-132	17 June 2005	O&M	2
134.	Letter from the Osh province BWMD to the NK BISA on the O&M of the Savai canal		25 June 2005	O&M	2
135.	Schedule from the NK BISA, MAWR Uzbekistan to the Jalalabad BWMD, Kyrgyzstan WMD on the Decadal water allocation of the Maylisai STT		2005	Water sharing	2
136.	Schedule from the NK BISA, MAWR Uzbekistan to the Jalalabad BWMD, Kyrgyzstan WMD on the Decadal water allocation of the Suzak canal		2005	Water sharing	2
137.	Schedule from the NK BISA, MAWR Uzbekistan to the Jalalabad BWMD, Kyrgyzstan WMD on the Decadal water allocation of the Right-shore Kampyr-Ravat (RSKR) canal		2005	Water sharing	2
138.	Letter from the KM ISA to the Jalalabad province, Nookent district administration on crossing the border for O&M of the Dustlik and Mustakillik 8 yilligi canals		15 July 2006	O&M, border crossing	2
139.	Letter from the NK BISA to the Jalalabad BWMD on crossing the border for O&M of the Pump-stations		17 July 2006	O&M, border crossing	2
140.	Letter from the NK BISA to the Jalalabad BWMD on the Accident, O&M of the M 1-2 canal		11 October 2006	O&M	2
141.	Letter from the NK BISA to the Jalalabad BWMD on the O&M of the M 1-1 and M 1-2 canals of Dustlik pump-station		25 October 2006	O&M	2
142.	Protocol of the negotiations of the government delegations of Uzbekistan and Tajikistan (on Kayrakkum)		26 December 2006	Water sharing, issue linkages	2
143.	Letter from the NK BISA to the Osh BWMD on increasing water supply of the Akburasai and Aravansai STTs		02 May 2008	Water sharing	2

Table S1. *Cont.*

Chronological order of the document	Document [1]	NO.	Date	Relevance to (Present) Benefit Sharing [2]	Type [4] of Benefits [3]
144.	Schedule from the NK BISA to the Jalalabad BWMD on the Decadal water allocation of the Maylisai STT		2008	Water sharing	2
145.	Schedule from the NK BISA to the Jalalabad BWMD on the Decadal water allocation of the Druzhba pump-station		2008	Water sharing	2
146.	Letter from the Savai-Akbura (SA) ISA to the Aravan district Interior affairs department on crossing the border for O&M of the Aravansai STT		30 January 2009	O&M, border crossing	2
147.	Schedule from the KM ISA, NK BISA to the Jalalabad BWMD on the Decadal water allocation of the Druzhba pump-station		05 February 2009	Water sharing	2
148.	Letter from the SA ISA to the Aravan district Interior affairs department on crossing the border for O&M of the Aravansai STT		16 March 2009	O&M, border crossing	2
149.	Letter from the SA ISA to the Aravan district Interior affairs department on crossing the border for O&M of the Aravansai STT		30 September 2009	O&M, border crossing	2
150.	Schedule from the NK BISA to the Jalalabad BWMD on the Decadal water allocation of the Pakhta-Abad canal from Karadarya river		2009	Water sharing	2
151.	Report from the Jalalabad province WMD on the STTs. Jalalabad province WMD		2009	Water sharing, linked issues	2
152.	Letter from the SA ISA to the Aravan district Interior affairs department on crossing the border for O&M of the Aravansai STT		30 January 2010	O&M, border crossing	2
153.	Letter from the SA ISA to the Osh province administration on flood, crossing the border of the Azimboy canal		May 2010	O&M, border crossing	2
154.	Letter from the SA ISA to the Aravan district WMD on flood, crossing the border of the Azimboy canal		May 2010	O&M, border crossing	2
155.	Letter from the SA ISA to the Aravan district interior affairs department on flood, crossing the border of the Azimboy canal		May 2010	O&M, border crossing	2
156.	Letter from the Jalalabad province, Nookent district administration to the Andijan province WMD (NK BISA) on crossing the border for O&M of the Pump-stations Druzhba, Mustakillik 8-yilligi, Madaniyat		16 June 2010	O&M, border crossing	2
157.	Report from the Jalalabad province WMD on the STTs. Jalalabad province WMD		2010	Water sharing, linked issues	2
158.	Letter from the KM ISA to the Shamaldisai Unit of the border authority of Kyrgyzstan on crossing the border for O&M of the M-1, M-1-1, M-1-2, Druzhba approach and pumping canals		14 February 2011	O&M, border crossing	2

Table S1. *Cont.*

Chronological order of the document	Document [1]	NO.	Date	Relevance to (Present) Benefit Sharing [2]	Type [4] of Benefits [3]
159.	Letter from the KM ISA to the Jalalabad province, Nookent district Burgandy village administration on crossing the border for O&M of the M-1, M-1-1, M-1-2, Druzhba approach and pumping canals		14 February 2011	O&M, border crossing	2
160.	Letter from the KM ISA to the Jalalabad province, Customs authority on crossing the border for O&M of the M-1, M-1-1, M-1-2, Druzhba approach and pumping canals		14 February 2011	O&M, border crossing	2
161.	Letter from the KM ISA to the Jalalabad province, Nookent district administration on crossing the border for O&M of the M-1, M-1-1, M-1-2, Druzhba approach and pumping canals		14 February 2011	O&M, border crossing	2
162.	Letter from the SA ISA to the Aravan district Interior affairs department on crossing the border for O&M of the Aravansai STT		21 February 2011	O&M, border crossing	2
163.	Letter from the SA ISA to the Aravan district Interior affairs department on crossing the border for O&M of the Aravansai STT		08 April 2011	O&M, border crossing	2
164.	Letter from the SA ISA to the Aravan district administration on crossing the border for O&M of the Aravansai STT		20 April 2011	O&M, border crossing	2
165.	Letter from the NK BISA to the Jalalabad BWMD on increasing water supply of the Maylisai STT		10 July 2011	Water sharing	2
166.	Letter from the NK BISA to the Nookent district administration on increasing water supply of the Maylisai STT		11 July 2011	Water sharing	2
167.	Letter from the NK BISA to the Nookent district administration on increasing water supply of the Maylisai STT		04 August 2011	Water sharing	2
168.	Letter from the NK BISA to the Jalalabad BWMD on increasing water supply of the Maylisai STT		04 August 2011	Water sharing	2
169.	Letter from the Jalalabad BWMD to the NK BISA on crossing the border for O&M of the RSKR canal		12 September 2011	O&M, border crossing	2
170.	Letter from the Pump stations, energy and comm. dept. of NK BISA to the Jalalabad province, Nookent district administration on crossing the border for O&M of the Pump-stations Druzhba, Mustakillik 8-yilligi		10 January 2012	O&M, border crossing	2
171.	Letter from the KM ISA to the Shamaldisai Unit of the border authority of Kyrgyzstan on crossing the border for O&M of the M-1, M-1-1, M-1-2, Druzhba approach and pumping canals		17 January 2012	O&M, border crossing	2

Table S1. *Cont.*

Chronological order of the document	Document [1]	NO.	Date	Relevance to (Present) Benefit Sharing [2]	Type [4] of Benefits [3]
172.	Letter from the KM ISA to the Jalalabad province, Customs authority on crossing the border for O&M of the M-1, M-1-1, M-1-2, Druzhba approach and pumping canals		17 January 2012	O&M, border crossing	2
173.	Letter from the KM ISA to the Jalalabad province, Nookent district Burgandy village administration on crossing the border for O&M of the M-1, M-1-1, M-1-2, Druzhba approach and pumping canals		17 January 2012	O&M, border crossing	2
174.	Letter from the Savai-Akbura (SA) ISA to the Osh province BWMD on the O&M of the Savai canal	01-09-18	27 February 2012	O&M	2
175.	Letter from the Andijan province administration to the Border Authoritiy Sharq on crossing the border for O&M of the Pump-stations Druzhba, Mustakillik 8-yilligi		31 March 2012	O&M, border crossing	2
176.	Letter from the Osh BWMD to the NK BISA on increasing water supply of the Kyzyl Bayraq canal		17 July 2012	Water sharing	2
177.	Letter from the Osh BWMD to the NK BISA on increasing water supply of the Kyzyl Bayraq canal		08 August 2012	Water sharing	2
178.	Schedule from the Unified authority of main canals, MAWR Uzbekistan to the Jalalabad BWMD, Kyrgyzstan WMD on the Decadal water allocation of the RSKR canal		2012	Water sharing	2
179.	Schedule from the NK BISA, MAWR Uzbekistan to the Jalalabad BWMD, Kyrgyzstan WMD on the Decadal water allocation of the Pakhta-Abad canal from Karadarya river		2012	Water sharing	2
180.	Schedule from the NK BISA, MAWR Uzbekistan to the Osh BWMD, Kyrgyzstan WMD on the Decadal water allocation of the Aravansai STT		2012	Water sharing	2
181.	Schedule from the NK BISA, MAWR Uzbekistan to the Osh BWMD, Kyrgyzstan WMD on the Decadal water allocation of the Akburasai STT		2012	Water sharing	2
182.	Schedule from the NK BISA, MAWR Uzbekistan to the Osh BWMD, Kyrgyzstan WMD on the Decadal water allocation of the Savai canal		2012	Water sharing	2
183.	Report from the Osh province WMD on the shared water resources. Osh province WMD		2012	Water sharing, linked issues	2
184.	Report from the Ferghana province WMD on the STTs. Ferghana province WMD—Sirdarya-Sokh BISA (in Uzbek).		2012	Water sharing, linked issues	2
185.	Report from the Jalalabad province WMD on the STTs. Jalalabad province WMD		2012	Water sharing, linked issues	2
186.	Letter from the KM ISA to the Jalalabad province, Nookent district Burgandy village administration on crossing the border for O&M of the M-1, M-1-1, M-1-2, Druzhba approach and pumping canals		01 February 2013	O&M, border crossing	2

Table S1. *Cont.*

Chronological order of the document	Document [1]	NO.	Date	Relevance to (Present) Benefit Sharing [2]	Type [4] of Benefits [3]
187.	Letter from the KM ISA to the Jalalabad province, Customs authority on crossing the border for O&M of the M-1, M-1-1, M-1-2, Druzhba approach and pumping canals		01 February 2013	O&M, border crossing	2
188.	Letter from the KM ISA to the Jalalabad province, Nookent district administration on crossing the border for O&M of the M-1, M-1-1, M-1-2, Druzhba approach and pumping canals		01 February 2013	O&M, border crossing	2
189.	Letter from the Jalalabad province, Nookent district administration to the Andijan province WMD (NK BISA) on crossing the border for O&M of the Pump-stations Druzhba, Mustakillik 8-yilligi, Madaniyat		2013	O&M, border crossing	2
190.	Report from the Jalalabad province WMD on the STTs. Jalalabad province WMD		2013	Water sharing, linked issues	2

Notes: [1] The originals of documents are in Russian language unless otherwise stated; [2] Some pivotal, in the authors' opinion, documents which may have likely influenced the level of autonomy in decision making and strategic priorities are highlighted in grey; [3] Due to the great heterogeneity of the levels, actors, objects and other details involved, the results are descriptive and do not imply a numeric accuracy, on the same grounds the results are not aggregated.

Table S2. Agreements of the Central Asian states related to management of shared water resources after 1991.

Chronological order of the document	Date	Agreement/Institutional Arrangements	Purpose and Brief Content/Accomplishments	Basin and Governance Level	Validity at Present
1.	18 February 1992	Almaty Agreement on cooperation in the field of joint water resources management and conservation of interstate sources	To establish the ICWC, the two BWOs—Amu Darya and Syr Darya—property rights for the structures operated by these organizations. It was agreed to respect the existing pattern and principles of water allocation as well as acting regulations on water allocation from interstate sources	The entire Aral Sea basin, regional level	Yes
2.	04 January 1993	Decision of heads of the Central Asian states on creation of the International Fund for Saving the Aral Sea (IFAS)	To establish an organization which would manage the funds of the member states and international donors	The entire Aral Sea basin, regional level	Updated by the Ashgabat Agreement

Table S2. *Cont.*

Chronological order of the document	Date	Agreement/Institutional Arrangements	Purpose and Brief Content/Accomplishments	Basin and Governance Level	Validity at Present
3.	26 March 1993	Kzyl-Orda Agreement on Joint Activities in the Aral Sea Basin	To address environmental, social and economic issues in the basin. The Agreement established the Interstate Council on the problems of the Aral Sea basin (ICAS) which included: its Executive Committee located in Tashkent, Commission for Socio-Economic Development and Scientific, Technical and Environmental Cooperation (CSEDSTEC) and ICWC founded under the 1992 Agreement	The entire Aral Sea basin, regional level: signed between heads of the five states, Russia is included as an observer with technical and financial assistance and cooperation	Updated by the Ashgabat Agreement
4.	20 September 1995	Nukus Declaration	To confirm intentions and financial obligations towards the established interstate organizations	The entire Aral Sea basin, regional level	Yes
5.	28 February 1997	Almaty Declaration	To declare 1998 as the Year of protection of the environment in the region. The Declaration recognizes the need for ecosystem approach in managing the shared water resources	The entire Aral Sea basin, regional level	Yes
6.	17 March 1998	Bishkek Agreement on cooperation in the area of environment and rational nature use	To cooperate in the field of environmental protection, harmonize environmental laws, improve economic mechanisms and other measures	Three countries: Kazakhstan, Kyrgyzstan and Uzbekistan, regional level	Yes
7.	17 March 1998	Syr Darya Framework Agreement	To create a framework where energy resources could be exchanged among the states. Summer hydropower from Kyrgyzstan (later from Tajikistan as well) to Uzbekistan and Kazakhstan, winter fossil fuels from Uzbekistan and Kazakhstan to Kyrgyzstan (and Tajikistan)	Kazakhstan, Kyrgyzstan and Uzbekistan signed the Agreement in 1998 and Tajikistan joined in 1999, regional level	No
8.	09 April 1999	Ashgabat Agreement on the status of the IFAS	To define the new structure and status of the IFAS and its organizations, which included (1) Board of IFAS; (2) A revision Committee; (3) Executive Committee (EC); (4) Branches of EC of the IFAS in the states; (5) ICWC, with its Secretary, Scientific Information Center (SIC ICWC), Basin Water Management Organizations (BWO) Amu Darya and Syr Darya; (6) The Commission on the Sustainable Development (CSD) with its Secretary, Scientific Information Center at Institute of Deserts of Turkmenistan (SIC CSD)	The entire Aral Sea basin, regional level	Yes
9.	09 April 1999	Ashgabat Declaration	To re-affirm the continuation of joint actions to address environmental problems and issues related to use of natural resources. In particular, the Declaration commits more consideration to the problems of mountain territories zones of the rivers flow formation	The entire Aral Sea basin, regional level	Yes

Table S2. *Cont.*

Chronological order of the document	Date	Agreement/Institutional Arrangements	Purpose and Brief Content/Accomplishments	Basin and Governance Level	Validity at Present
10.	17 June 1999	Bishkek Agreement on hydro-meteorology	To harmonize the activities in the field of hydro-meteorology	Four countries: Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan, regional level	Yes
11.	17 June 1999	Bishkek Agreement on parallel operation of the national energy systems	To set up a common coordinated energy platform, which in parallel with the existing agreements on water and energy (Syr Darya Framework Agreement), was supposed to synchronize joint activities in the field	Four countries: Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan, regional level	No
12.	21 January 2000	Astana Agreement—Chu Talas	To establish a framework to jointly manage the rivers Chu and Talas shared by the Kyrgyzstan and Kazakhstan	Two countries: Kazakhstan and Kyrgyzstan, regional level	Yes
13.	06 October 2002	Dushanbe Declaration	To define the main directions in addressing problems related to the Aral Sea basin, improve monitoring and information sharing systems among the countries	The entire Aral Sea basin, regional level	Yes

Table S3. Main characteristics of the transboundary infrastructure constructed in the period from 1924 to 2013 in Andijan and Ferghana provinces of Uzbekistan shared with Batken, Jalalabad, Osh provinces of Kyrgyzstan and Sogd province of Tajikistan, adapted from [27].

Name of the Infrastructure	Infra-structure Type	Water Flow Capacity, m^3/s	Date of Construc-tion	Budget of Which Country	Total Length (canals), km	Length Located in Other Country, km	Total Command Area, ha	Area in Other Country, ha	District Served Own Country	District Served Other Country	Who Operated during Soviet Union	Who Owns Today or Operates	How Many Times Crosses the Border	Location of Headwork/ Infra-Structure
PerioD from 1920S to 1953														
Chimgansay	S	20	1924	UZ	13.2	10.89	285	0	Ferghana (UZ)	Kadamjay (KG)	F-R (UZ)	F-B of I-Sh ISA (UZ)	1	KG
Arabtepasay	S	6	1924	UZ	26.4	12.58	1,944	300	Ferghana (UZ)	Kadamjay (KG)	I-Sh DICFC (UZ)	I-Sh ISA (UZ)	3	KG
Altiariksay	S	40	1924	UZ	13.3	12.12	4,520	0	Ferghana (UZ)	Kadamjay (KG)	I-Sh DICFC (UZ)	I-Sh ISA (UZ)	1	UZ
Eski Fayziabadsai	S	10	1924	UZ	29.3	6.6	6,375	0	Ferghana (UZ)	Kadamjay (KG)	I-Sh DICFC (UZ)	I-Sh ISA (UZ)	4	UZ
Hilla Canal	IC	13	1934	UZ	11.2	7.2	5,980	2,500	Pakhtaabad (UZ)	Nookent (KG)	M-S MIDC (UZ)	K-M ISA (UZ))	1	KG
Kuykulak Canal	IC	6	1934	UZ	4	1.2	3,556	0	Pakhtaabad (UZ)	Nookent (KG)	M-S MIDC (UZ)	K-M ISA (UZ)	1	KG
Savai Canal	IC	30	1936	UZ	55.9	28.5	17,000	3500	Kurgantepa (UZ)	Karasuy (KG)	P-R (UZ)	K-M ISA (UZ)	1	UZ

Table S3. *Cont.*

Name of the Infrastructure	Infra-structure Type	Water Flow Capacity, m^3/s	Date of Construc-tion	Budget of Which Country	Total Length (canals), km	Length Located in Other Country, km	Total Command Area, ha	Area in Other Country, ha	District Served Own Country	District Served Other Country	Who Operated during Soviet Union	Who Owns Today or Operates	How Many Times Crosses the Border	Location of Headwork/ Infra-Structure
Rovot water distribution facility	WO	60	1936	UZ	n/a	n/a	n/a	n/a	Besharyk (UZ)	Konibodom (TJ)	B-R (UZ)	Isfara-Syr ISA (UZ)	0	TJ
Rapkon Main Canal	IC	4	1936	UZ	2	1	682	0	Besharyk (UZ)	Isfara (TJ)	B-R (UZ)	Isfara-Syr ISA (UZ)	1	TJ
Logon Canal	IC	16	1937	UZ	29.5	15.9	16,000	4,000	Ferghana (UZ)	Kadamjay (KG)	I-Sh DICFC (UZ)	I-Sh ISA (UZ)	2	KG-UZ
Ferghana Canal	IC	1.5	1946	UZ	4.8	3	1,200	0	Ferghana (UZ)	Kadamjay (KG)	I-Sh DICFC (UZ)	I-Sh ISA (UZ)	1	KG
SUB-TOTAL: 1920s-1953		206.5			189.6	98.99	57,542	10,300						6 in KG, 4 in UZ, 2 in TJ
Period from 1953 to 1970														
Madaniyat Pumping Canal	IC	3	1958	UZ	11.9	2.4	1600	500	Pakhtaabad (UZ)	Nookent (KG)	M-S MIDC (UZ)	K-M ISA (UZ)	1	KG
Madaniyat-1	PS	0.72	1958	UZ	n/a	n/a	see Madaniyat Pumping Canal	see Madaniyat Pumping Canal	Pakhtaabad (UZ)	Nookent (KG)	M-S MIDC (UZ)	K-M ISA (UZ)	0	UZ
Sokh-Shakhimardan	IC	30	1959	UZ	30.5	18.2	16,000	3,000	Rishtan (UZ), Oltiarik (UZ)	Kadamjay (KG)	S-O DICFC (UZ)	S-O ISA (UZ)	1	UZ
Mustakillik 8 Yilligi Approach Canal	WO	11	1960	UZ	8.8	2.3	420	n/a	Pakhtaabad (UZ)	Nookent (KG)	M-S MIDC (UZ)	K-M ISA (UZ)	1	KG
Uz. Mustakillik 8 Yilligi, 1-elevation	PS	8.4	1960	UZ	n/a	n/a	see M-1-1 and M-1-2 Pumping Canals	see M-1-1 and M-1-2 Pumping Canals	Pakhtaabad and Izbaskan (UZ)	Nookent (KG)	M-S MIDC (UZ)	K-M ISA (UZ)	0	KG

Table S3. *Cont.*

Name of the Infrastructure	Infra-structure Type	Water Flow Capacity, m^3/s	Date of Construc-tion	Budget of Which Country	Total Length (canals), km	Length Located in Other Country, km	Total Command Area, ha	Area in Other Country, ha	District Served Own Country	District Served Other Country	Who Operated during Soviet Union	Who Owns Today or Operates	How Many Times Crosses the Border	Location of Headwork/ Infra-Structure
Uz. Mustakillik 8 Yilligi, 2-elevation	PS	0.8	1960	UZ	n/a	n/a	see M-1-1 and M-1-2 Pumping Canals	see M-1-1 and M-1-2 Pumping Canals	Izbaskan (UZ)	Nookent (KG)	M-S MIDC (UZ)	K-M ISA (UZ)	0	KG
Khurromobod Canal	IC	1.5	1960	UZ	2.39	2.4	1,135	0	Rishtan (UZ)	Kadamjay (KG)	S-O DICFC (UZ)	S-O ISA (UZ)	1	KG
Kishtut Canal	WF	0.6	1961	UZ	1.2	1.2	520	0	Sokh (UZ)	Kadamjay (KG)	S-R (UZ)	S-B of S-O ISA (UZ)	1	KG
Tayon Canal	IC	0.3	1962	UZ	0.2	0.2	120	0	Sokh (UZ)	Kadamjay (KG)	S-R (UZ)	S-B of S-O ISA (UZ)	1	KG
M-1 Pumping Canal	WO	9	1962	UZ	1.8	1.8	0	0	Izbaskan (UZ)	Nookent (KG)	M-S MIDC (UZ)	K-M ISA (UZ)	1	KG
M-1-1 Pumping Canal	IC	3.8	1962	UZ	7.6	7.6	3,100	300	Pakhtaabad (UZ)	Nookent (KG)	M-S MIDC (UZ)	K-M ISA (UZ)	1	KG
M-1-2 Pumping Canal	IC	6	1962	UZ	8.6	8.6	3,759	200	Pakhtaabad (UZ)	Nookent (KG)	M-S MIDC (UZ)	K-M ISA (UZ)	1	KG
Navruz Canal	IC	3.5	1964	UZ	10	7	752	0	Rishtan (UZ)	Kadamjay (KG)	S-O DICFC (UZ)	S-O ISA (UZ)	1	KG
Tashlak Canal	IC	3	1966	UZ	8.1	0.8	650	50	Pakhtaabad (UZ)	Nookent (KG)	M-S MIDC (UZ)	K-M ISA (UZ)	1	KG
Dustlik	PS	8.4	1969	UZ	n/a	n/a	see Dustlik Pumping Canal	see Dustlik Pumping Canal	Pakhtaabad and Izbaskan(UZ)	Nookent (KG)	M-S MIDC (UZ)	K-M ISA (UZ)	0	KG
SUB-TOTAL: 1953-1969		90.02			91.09	52.5	28,056	4,050						13 in KG, 3 in UZ
Period in 1970s														
Dustlik Approach Canal	WO	18.0	1970	UZ	13.5	13.5	5,978	1,895	Pakhtaabad and Izbaskan(UZ)	Nookent (KG)	M-S MIDC (UZ)	K-M ISA (UZ)	1	KG
Dustlik Pumping Canal	IC	9.5	1970	UZ	19	10.9	7,769	2,700	Pakhtaabad and Izbaskan(UZ)	Nookent (KG)	M-S MIDC (UZ)	K-M ISA (UZ)	1	KG
Dustlik Emergency Spillway	FC	11.5	1970	UZ	7.4	7.4	0	0	Pakhtaabad and Izbaskan(UZ)	Nookent (KG)	M-S MIDC (UZ)	K-M ISA (UZ)	1	KG
Koshkaryon Flood controlling dam	FC	15.0	1970	UZ	2.7	2.7	n/a	n/a	Rishtan (UZ)	Kadamjay (KG)	R-R (UZ)	R-B of S-O ISA UZ)	1	KG
Jiyda Canal PPO+00-38-00	IC	2.0	1974	UZ	3.81	3.81	905	0	Ferghana (UZ)	Kadamjay (KG)	F-R (UZ)	F-B of I-Sh ISA (UZ)	0	KG

Table S3. *Cont.*

Name of the Infrastructure	Infra-structure Type	Water Flow Capacity, m^3/s	Date of Construc-tion	Budget of Which Country	Total Length (canals), km	Length Located in Other Country, km	Total Command Area, ha	Area in Other Country, ha	District Served Own Country	District Served Other Country	Who Operated during Soviet Union	Who Owns Today or Operates	How Many Times Crosses the Border	Location of Headwork/ Infra-Structure
Mindon 1 flood controlling dam	FC	1.5	1978	UZ	2.5	1.3	n/a	n/a	Ferghana (UZ)	Kadamjay (KG)	I-Sh DICFC (UZ)	I-Sh ISA (UZ)	0	KG
Mindon 2 flood controlling dam	FC	1.5	1978	UZ	2	1.2	n/a	n/a	Ferghana (UZ)	Kadamjay (KG)	I-Sh DICFC (UZ)	I-Sh ISA (UZ)	0	KG
Sub-total: 1970s		59			50.91	40.81	14,652	4,595						7 in KG
Period from 1980 to 1991														
Suzok-5	IC	0.5	1987	UZ	0.95	0.95	362	0	Pakhtaabad (UZ)	Bazarkurgan (KG)	M-S MIDC (UZ)	K-M ISA (UZ)	1	KG
Kurgantepa Canal	IC	2.0	1988	UZ	5.17	1.3	528	0	Ferghana (UZ)	Kadamjay (KG)	F-R (UZ)	F-B of I-Sh ISA (UZ)	2	UZ
Khalmiyon flood controlling dam	FC	7.5	1988	UZ	3.2	3.2	n/a	n/a	Ferghana (UZ)	Kadamjay (KG)	I-Sh DICFC (UZ)	I-Sh ISA (UZ)	0	KG
Kurgantepa flood controlling dam	FC	2.0	1988	UZ	15.7	1.3	n/a	n/a	Ferghana (UZ)	Kadamjay (KG)	I-Sh DICFC (UZ)	I-Sh ISA (UZ)	0	KG
Mindon flood controlling dam	FC	14.0	1990	UZ	3.3	3.3	n/a	n/a	Ferghana (UZ)	Kadamjay (KG)	I-Sh DICFC (UZ)	I-Sh ISA (UZ)	0	KG
Sub-total: 1980-1990		26			28.32	10.05	890	0						4 in KG, 1 in UZ
Period from 1991 to Present														
Yarkuton flood controlling dam	FC	20.0	1992	UZ	8.1	8	n/a	n/a	Ferghana (UZ)	Kadamjay (KG)	I-Sh DICFC (UZ)	I-Sh ISA (UZ)	0	KG
Kanda flood water dumping	FC	25.0	1999	UZ	1	1	n/a	n/a	Ferghana (UZ)	Kadamjay (KG)	I-Sh DICFC (UZ)	I-Sh ISA (UZ)	0	KG
Madaniyat-2	PS	0.72	2006	UZ	n/a	n/a	see Madaniyat Pumping Canal	see Madaniyat Pumping Canal	Pakhtaabad (UZ)	Nookent (KG)	M-S MIDC (UZ)	K-M ISA (UZ)	0	KG
Sub-total:]1991-present		45.72			9.1	9	0	0						3 in KG
Total		427.24			369.02	211.35	101,140	18,945						37 in KG, 8 in UZ, 2 in TJ

Abbreviations

B-R: Besharyk Rayvodkhoz; DICFC: Department of Inter-Collective Farm canals; F-B: Ferghana Branch; FC: Flood control and dam; F-R: Ferghana Rayvodkhoz; IC: Irrigation Canal; ISA: Irrigation System Authority; Isfara-Syr: Isfara-Syr Darya; I-Sh: Isfayram-Shahimardan; KG: Kyrgyz Republic; K-M: Karadarya–Maylisai; Mid Srh: Mid-Sharikhan; MIDC: Management of Inter-District Canals; M-S: Maylisai; PC: Pump Canal; P-R: Pakhtaabad Rayvodkhoz; PS: Pump station; R-B: Rishtan Branch; R-R: Rishtan Rayvodkhoz; S: Small River; S-A: Savay-Akbura; S-B: Sokh Branch; S-O: Sokh-Oktepa; S-R: Sokh Rayvodkhoz; TJ: Republic of Tajikistan; Up Srh: Upper Sharikhan; UZ: Republic of Uzbekistan; WF: Water flume meters; WO: Water Outlets.

3 Water Security in the Syr Darya Basin

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Article

Water Security in the Syr Darya Basin

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Abstract: The importance of water security has gained prominence on the international water agenda, but the focus seems to be directed towards water demand. An essential element of water security is the functioning of public organizations responsible for water supply through direct and indirect security approaches. Despite this, there has been a tendency to overlook the water security strategies of these organizations as well as constraints on their operation. This paper discusses the critical role of water supply in achieving sustainable water security and presents two case studies from Central Asia on the management of water supply for irrigated agriculture. The analysis concludes that existing water supply bureaucracies need to be revitalized to effectively address key challenges in water security.

Keywords: water security; supply water security; irrigation bureaucracy; polycentric water management; transboundary; Central Asia

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1. Introduction

Since the 1990s, water infrastructure security and security of water supply became important topics with regards to conflict [1] and terrorism [2,3] specifically related to water. Today, water security is even more dominant on the agenda of the international water community and three international organizations (the Global Water Partnership, the United Nations University, and the International Water Management Institute) adopted the term as a guiding framework. Current water security definitions refer to key demands or objectives of users and the ecosystem in a changing environment [4,5]. In addition to this global focus on water security, the water, energy and food nexus builds around water security objectives [6]. With the emphasis put on these objectives, more traditional approaches to water supply security, such as direct and indirect water security measures, are omitted.

An important factor of indirect water security is infrastructure. Infrastructure development for irrigated agriculture had its peak in the late 1970s (measured by World Bank lending) and was from then on a decline [7]. Today, mainly because of population pressure, new water infrastructure development is again on the agenda [8]. New large scale water infrastructure could also be an important aspect of polycentric water management within basins [9,10]. Some of the past investments in large scale water infrastructure are based on the fragmentation of former colonies and new national water security approaches, such as the construction of link-canals in the Indus Basin in Pakistan [11]. This paper contributes to the literature on indirect water security approaches in a recently fragmented basin, the Syr Darya in Central Asia. International literature on water security in the Syr Darya Basin often focuses on large transboundary infrastructure such as the Toktogul and Kayrakum reservoirs in Kyrgyzstan and Tajikistan, respectively, as well as the planned new Kambarata 1 and 2 reservoirs in Kyrgyzstan. The prominent nature of the water-energy nexus in large water infrastructures, such as in the Syr Darya Basin, has also brought a focus on related energy security [12,13]. Hence, in the Syr Darya Basin, water and energy security focus mainly on the main river as well as its larger reservoirs. This focus ignores important aspects of historical design. The Soviet Union designed and planned water management at basin level as well as Smaller Transboundary Tributaries (STTs) and smaller infrastructure such as main canals, reservoirs or pump station schemes [14–17].

Direct water security in large scale irrigation systems has been the responsibility of irrigation bureaucracies in the past [18,19]. However, with the exception of some early experiences, Irrigation Management Transfer (IMT) became a national strategy in most developing countries in the 1980s and 1990s [20]. IMT shifts the responsibility of direct water security from the government to the users, organized in newly created Water User Associations (WUAs). While IMT and WUAs have been in the past widely promoted [21,22], more recently there have been doubts [23,24]. With the focus on IMT the lower level bureaucracy is "handed over" [25,26] and the higher level bureaucracy focuses on other functions or focuses only on the higher level like basin management [27]. Here, a case study is presented on partial IMT in one province of Uzbekistan. When focusing on water security for irrigated agriculture within Uzbekistan, so far the emphasis has been on the introduction of winter wheat (as policy to increase food security) and therefore the reduction of irrigated area under cotton [28,29] as well as creating WUAs [30,31]. The water supply organizations, the irrigation departments, have received little international attention, although they were incorporated in some donor projects.

This paper discusses both indirect and direct water supply security measures in irrigated agriculture by drawing from evidence from the Syr Darya basin and Ferghana Province, Uzbekistan. The focus on water supply, rather than on water demand security, is meant to draw attention to the way in which water management, with particular focus on irrigated agriculture, was organized. This focus on past water supply security approaches attempts to challenge the current focus of the international research community on basins and large infrastructure [12,13]. This paper also points out weaknesses in the current promotion of IMT especially at the main canal level–which shifts water supply security from the government to the water users for agricultural water uses [32,33].

The presented case study is structured into two sections. The data for the first section is based on a literature review and interviews with a key informer of the Syr Darya basin water organization (BWO) in 2014. The data presented in the second section is based on archival research of annual reports of the Ferghana Province Irrigation Department in Uzbekistan. The annual reports studied cover a period from 1978 up to 2010. Key informers of the Ferghana and Andijan Province Irrigation Departments were interviewed regarding verification of reported trends.

The paper continues with a short framework section on water security. The following case study is structured into two sections. The first section focuses on water supply security within the Syr Darya and the associated challenges faced by past and current irrigation water management strategies at the irrigation district level. The second section focuses on water security approaches within Ferghana Province and highlights changing water demands as well as the water security approaches taken so far. Within the section, large emphasis is put on the irrigation departments which after Uzbekistan's independence were not incorporated in achieving water security. Each case study is followed by a short discussion. A broader discussion follows, highlighting the possibly national as well as international reasons for not focusing on water supply organizations, which appear to have become the weakest link in water security. The conclusion stresses the need to look at poly-centric water management and a refocus on water supply organizations.

2. Water Security

As Allouche *el al.* [34] noticed "historically security has been concerned with safety and therefore can be understood as the condition of being protected from, or not exposed to, danger". Water security by the turn of the century focused on these traditional aspects. The security of larger water supply infrastructure was voiced in the debate on water wars [1], terrorism [2,3] as well as cyber-attacks [35]. While these perceived insecurities have been dismissed, they have also triggered calls for heightened security and additional systems of resilience [35,36].

More recently, the term water security gained prominence in the international literature from a different perspective. UN-water [4] defines water security as "The capacity of a population to safeguard sustainable access to adequate quantities of and acceptable quality of water for sustaining livelihoods, human well-being, and socio-economic development for ensuring protection against water-borne pollution and water-related disasters and for preserving ecosystems in a climate of peace and political stability". The definition mainly focuses on the demand side and objectives of water security. While this broad definition of water security focusses on access and is human centered ("capacity of a population"), it critically lacks reference to the supply-side of water security. Water supply is vaguely addressed and

seems to extend the responsibility of water security to the wider public by making reference to 'a population'. As answer to the current challenge of water security, UN-water [4] calls for "tailored policy responses", human "capacity development" and "improved water governance". Water service providers, their challenges and strategies how to meet water demands are not directly addressed. The focus on human "capacity building" seems to neglect the human ingenuity in developing countries to cope with water insecurity. As Allouche *et al*. [34] highlights, "Missing […] is the issue of security sought by households in the South, many of whom exist within the vast informal economy, through which they survive and cope with external circumstances".

Grey and Sadoff [5] define water security as "the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environments and economies. Lautze and Manthrithilake [37] highlight that Grey and Sadoff's "broader treatment of risks strongly suggests inclusion of issues related to water for national security or independence". Sadoff *et al.* [38], when defining pathways to water security, put the emphasis on institutions, information and infrastructure. Sadoff *et al.* [38] see institutions as "formal laws, policies, regulations, and administrative organizations as well as informal networks and coalitions". According to them, institutions incorporate planning, financing, construction, operating, supplying, regulating, monitoring, enforcing and insuring. Hence, the main focus is on the public sector, and central are water supply organizations. Nevertheless, they [38] highlight the need for "a 'poly-centric' and multi-level governance system that has been described as an 'institutional tripod' involving water users, states and markets". The "institutional tripod" can be criticized from different perspectives such as diversity and power inequities of users within sectors [39–43] and competing sectors [44–46], market failure and the responsibility of markets for the water crisis [47,48] as well as states institutionalizing inequities through water rights reforms [42,49–51].

In the global debate on the water, energy and food nexus, although reference is made to water, energy and food security, the emphasis for all three is on "access" [6,47]. Different authors have highlighted that the water, energy and food nexus is under-conceptualized and that security in one is contradicting security of the other parts of the nexus [47,52,53]. Hoff [6] highlights "the emphasis on access in these definitions also implies that security is not so much about average (e.g., annual) availability of resources, but has to encompass variability and extreme situations such as droughts or price shocks, and the resilience of the poor". Hence, key would be to include in the debate the supply side of water security. Instead, Hoff [6] argues that "It is increasingly recognized that conventional supply side management is coming to an end in many cases". Nevertheless, he [6] calls for strengthening existing supply side institutions for building "new links across sectors and deal with the additional uncertainty, complexity and inertia when integrating a range of sectors and stakeholders". The assumption appears to be, that linking an undefined range of sectors and stakeholders together will by itself provide better "access". Overall, an analysis of existing water supply organizations, and their strategies to meet demands or encounter risks, is crucially missing.

Traditionally, securing water supply focused on planning and construction of large infrastructures to be able to capture and store water resources as well as satisfying urban and agricultural needs [54]. Infrastructure development was not only seen to increase indirect national water security within transboundary basins [11] but also to enable polycentric water management within basins [9,10].

Recently, due to population pressure, but also due to seasonal variability of water, a rising deficit of existing water infrastructure has been identified [8,55–57].

Looking at water supply security in irrigated agriculture, the aspect of service provision towards the users came to the forefront in the 1980s. There was a realization that the gap in maintenance of irrigation infrastructure [58] led to a deterioration of water supply services. In addition there was recognition of the failure of the irrigation bureaucracy for ensuring equity of water distribution between water users [59,60]. Both insights could be attributed to issues regarding the financial security of water supply services. However, colonial irrigation systems focused on water supply as well as demands. Water control was achieved through different components focusing on water infrastructure, the organization providing the service and water demand [61,62]. Looking at past colonial large scale irrigation systems Ertsen [18,19] highlights that water supply (infrastructure and organization) as well as demand was planned for in the British, French and Dutch irrigation systems. Because of rising political pressure, market development and also changes of land ownership and farm sizes the water control side in irrigated agriculture disintegrated [63,64]. The rising water demand within the existing irrigated area was not met with an expansion of water supply infrastructure and providing more water resources or a strengthening of the irrigation bureaucracy controlling the distribution of limited water resources. The failure to provide equitable distribution was attributed to the continuation of established control practices [65] as well as the overall low salaries of the irrigation bureaucracy and therefore the rise of corruption [66].

Similarly, in the 1990s with the fall of the iron curtain and with a focus on transitional economies, water service provision for urban areas rose high on the development agenda. Again, the focus was on maintenance of infrastructure as well as monitoring of water losses [67,68]. The failure of strengthening the supply side could be classified as financial insecurity triggering the decline in quality of water supply services.

Rising demands but also a failure to secure and increase water supply triggered the development of more resilient water supply systems, *i.e.*, cities established inter-linkages between different sources and water storage systems to cope with temporary supply shortages [69]. Similarly, for supporting irrigated agriculture, countries or even smaller administrative units (like provinces) established resilient systems to cope with international or national transboundary water supply insecurities [11,70–73]. Common in all these formal systems of resilience is a diversified access to water resources as well as less reliance on one main supply infrastructure.

Looking at the debates within the water sector, risks to water security have been identified as transboundary and inter and intra sectorial competition, water pollution, unsustainable operation and maintenance as well as reliance on a single source or supply network. Therefore, water supply security could be defined as a resilient system capable of coping with shocks, abuses and threats through direct security measures (surveillance and guards) and indirect or more passive measures through increasing maintenance and additional or alternative water supply sources, duplication of or less reliance on critical infrastructure to better cope with temporary shortages in water source availability as well as water rights or allocations to cope with competitions.

3. Water Security Approaches in the Syr Darya Basin

3.1. Geographic Background to the Syr Darya Basin

The Syr Darya rises in the Tien Shan Mountains of Kyrgyzstan and terminates in the Aral Sea in Kazakhstan. It is the longest river in Central Asia, at 3019 km, with a catchment area of 219,000 km^2. Up to the confluence with the Karadarya (also from Kyrgyzstan) the Syr Darya is called the Naryn. The Syr Darya is shared between four riparian states, Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan. On its way to the Aral Sea, the Naryn crosses international boundaries between Kyrgyzstan and Uzbekistan when entering the Ferghana valley and within the valley between Uzbekistan and Tajikistan as the Syr Darya. When leaving the Farghana valley, the Syr Darya enters first Uzbekistan and then crosses into Kazakhstan (Figure 1).

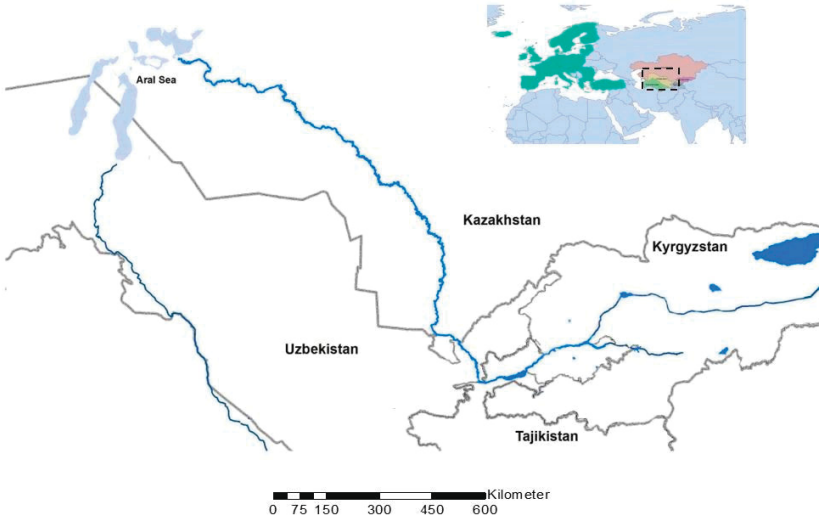

Figure 1. The Syr Darya Basin.

Due to large scale irrigation expansion, facilitated through the construction of multiple use reservoirs (Toktogul and Kayrakum), the Syr Darya basin closed in the 1980s [73,74]. The water allocation principles developed under the Schemes of Complex Use and Protection of Water Resources in the 1970s and early 1980s became the guiding principles of water allocation between the riparian states [17]. Later in 1987 the Syr Darya Basin Water Organization (BWO) was established [75]. Directly after independence, in 1992, the five Central Asian states came to an agreement to continue with these principles. However, while during the time of the Soviet Union the multiple use reservoirs operated to facilitate irrigated agriculture, after independence the operation of the reservoirs shifted mainly to winter releases for energy production to cover upstream riparian needs. The reason for the shift of operation is based on the collapse of existing compensation mechanisms. During the Soviet Union era, downstream states compensated for excess electricity produced at the reservoirs during the summer, by supplying fossil fuels and electricity during the winter.

3.2. The Common Approach to Look at Water Insecurity within the Syr Darya Basin

After independence the international emphasis on water security within the Syr Darya Basin focused on the conflicting interests of upstream hydropower production during the winter and downstream water needs for the agricultural sector during the summer. Therefore, the main emphasis was on the operation of the Toktogul reservoir and the brokering of an agreement on water and energy use in 1998. The agreement was amended to include the Kayrakum reservoir in Tajikistan in 1999. According to the agreement, purchases of energy and therefore water allocations from Toktogul are determined annually [76–78]. The implementation of the agreement has been seen as problematic in reference to water delivery to Kazakhstan [79,80] and as generally failed because of the late signing of annual bilateral agreements [78]. Overall, the primary focus of the international attempts to foster water security focused on the infrastructure controlling the main stem of the Syr Darya Basin, the Naryn, only [81]. However, the Naryn supplies about 40 percent (14.5 km^3) of the average annual flow of the Syr Darya River (37.2 km^3) only [81]. The focus on the Naryn River and the Toktogul reservoir assumed that basin management was the overarching principle. In addition, the agreement focused on national levels and did not incorporate Tajikistan as downstream water user [15].

3.3. Water Insecurity at the Meso-Level: Irrigation Districts and Within

Other research highlights that within the Syr Darya Basin, water management was organized according to "water-use regions" or "irrigation districts", which in some cases even crossed republican boundaries [82–84]. Within the Syr Darya Basin there were six irrigation districts during the Soviet era, these were: Upper Naryn, Ferghana Valley, Chirchik-Akhangaran-Keles (Chakir), Midstream, Arys-Turkestan (Artur) and Downstream (Figure 2). Three of these irrigation districts were transboundary: the Ferghana Valley irrigation district incorporated irrigated areas within the valley from Kyrgyzstan, Tajikistan and Uzbekistan; Chakir incorporated irrigated areas of Kazakhstan, Kyrgyzstan and Uzbekistan; and Mid-stream incorporated irrigated areas from Kazakhstan, Tajikistan and Uzbekistan.

Figure 2. Irrigation districts in the Syr Darya Basin.

Irrigation districts can be categorized into different groups with focus on the utilization of water sources, having access to alternative resources, and capturing winter flow (Table 1). The implication of former management according to irrigation districts is that the past system focused on poly-centric [9] and not basin-level water management and therefore crafted poly-centric water security approaches (storage and reliance on multiple sources). Therefore, the collapse of the Soviet Union and the emergence of independent states, as well as the shift of operation of the larger Toktogul reservoir in Kyrgyzstan did not create water insecurity for the whole basin, but created water insecurity for individual irrigation districts or parts of them.

Table 1. Features of irrigation districts (Source: adapted from [84,85].

Irrigation District	Source (km^3)	Storage (km^3)	Republic	Irrigated Land (1000 ha)	Total Water Use (km^3/year)
Upper Naryn	Naryn (14.5)	–	Kyrgyz SSR	130.3	–
Ferghana Valley	Naryn (14.5)	Toktogul: Total Storage (TS)-19.4 Active Storage (AS)-14.0	Uzbek SSR	409.8	4.69
			Tajik SSR	97.7	1.36
			Kyrgyz SSR	22.5	0.74
	Karadarya (3.9); Small Transboundary Tributaries (STT) (total 7.8)	Andijan: TS-1.9; AS-1.8; Some smaller transboundary reservoirs	Uzbek SSR	471.7	5.75
			Kyrgyz SSR	293.7	3.21
			Tajik SSR	30.5	0.23
Chakir	Chirchik (7.8); Akhangaran (0.7); Keles (0.3)	Charvak: TS-2.0; AS-1.6	Uzbek SSR	347.2	3.43
			Kyrgyz SSR	9.5	0.04
			Kazakh SSR	89	0.89
Mid-stream	Main stem	Kayrakum: TS-4.0; AS-2.6 Farkhad TS-0.15	Uzbek SSR	629.7	7.19
			Tajik SSR	87.6	1.03
			Kazakh SSR	117	1.34
	Small Tributaries (0.3)	–	Uzbek SSR	33.6	0.3
			Tajik SSR	30.5	0.23
Artur	Arys (1.2)	–	Kazakh SSR	200	–
Downstream	Main stem	Chardara:TS-5.7; AS-4.7	Kazakh SSR	374	–

The implication of looking at irrigation districts rather than the whole basin is that local water insecurity becomes more visible. Hence, after independence, irrigation districts were most water insecure if they were either dependent on one transboundary source only or if they were dependent on one transboundary infrastructure for capturing winter flows. Looking at the largest irrigator within the irrigation district only, the most potentially water insecure irrigation district would be Mid-stream. Here, the largest benefiter of the Mid-stream Kayrakum Reservoir is Uzbekistan; however, the reservoir is controlled by Tajikistan. In the case of the Ferghana Valley, although the main benefiter is Uzbekistan and the main reservoir is controlled by Kyrgyzstan, having access to alternative sources (Karadarya and small tributaries) as well as smaller reservoirs (Andijan as well as on small tributaries) could be interpreted as being in a less water insecure situation.

However, Table 1 also reveals that some irrigation districts are transboundary. Hence, within irrigation districts there is a second layer of potential water insecurity for transboundary parties. Within the Ferghana Valley irrigation district some areas experienced more potential water insecurity than others. These

potential insecurities are not related to the shift of Toktogul reservoir operation but more due to smaller transboundary infrastructure. Examples of these smaller infrastructures are the Big Namangan Canal, which is mainly supplying farmers in Uzbekistan. The diversion structure for the canal is located in Kyrgyzstan. In addition, within the Ferghana Valley and within smaller tributary basins downstream Uzbek areas are potentially water insecure, such as in the Isfara tributary [15]. Irrigated areas within Tajikistan are potentially water insecure if they depend on transboundary infrastructure, for example Tajikistan is at the tail-end of the Big Ferghana and North Ferghana Canals [15]. Although Kyrgyzstan is mainly upstream from the Ferghana valley, areas in Kyrgyzstan receive water through pump stations located in Uzbek territory or diversion from transboundary main canals, such as the South Ferghana Canal [14].

Within the mid-stream irrigation district, the Dustlik canal is transboundary and shared between Uzbekistan at the head-end and Kazakhstan at the tail-end [79,80]. Within the Dustlik canal Uzbekistan irrigates 98 thousand ha and Kazakhstan 125 thousand ha. Wegerich [86], comparing data from the years 1990 and 1991 with the years 2004 and 2005, shows that after independence Kazakhstan received less water and later during the cultivation period. Hence, for Kazakhstan along the Dustlik canal not the operation of Kayrakum reservoir appears to be the main factor, but the withdrawals along the Dustlik canal within Uzbekistan.

The Chakir irrigation district is independent of the operation of the Toktogul reservoir and is mainly based on water of tributaries, with only small diversion through lift from the Syr Darya to Uzbekistan (Dalverzin canal's command area) [87]. Within the irrigation district, Uzbekistan transfers water through three canals (Zakh, Khanym, and Big Keles) from the Chirchik river to the Keles massif irrigation system in Kazakhstan irrigating about 66 thousand ha [88], the same canals return water to Uzbekistan to irrigate about 17 thousand ha in Tashkent and Kibray districts [89]. Dukhovny *et al.* [88] report variation of water supplied to Kazakhstan. In the period 1995–2003 water supply varied between 347 and 595 km^3/year. It is not evident whether the mentioned 89 thousand ha [84] in Kazakhstan are all within the Keles massif and that therefore a major reduction of water supply occurred after independence. The major reduction could either be caused by a reduced total flow, or again as in the case of the Dustlik canal by withdrawals along the three main canals within Uzbekistan.

Overall, the irrigation district which was most water insecure after independence was dependent on one transboundary source (the main stem of the Syr Darya) and one transboundary infrastructure (reservoir). Similarly, areas within irrigation districts which were most water insecure to water supply shortages were dependent on transboundary infrastructure (main canals, pump stations) and had access to one transboundary water source (small transboundary tributary (STT) or main stem of the Syr Darya). The irrigation district which is the most water insecure is Mid-stream, and the areas being most water insecure within irrigation districts are some Uzbek and Tajik areas within the Ferghana Valley, Kazakh areas within the Mid-stream, and Kazakh as well as minor Uzbek areas within the Chakir irrigation districts.

4. Past and Current Water Security Approaches: Capturing Winter Flow and Alternative Sources

4.1. Past Water Security Approaches–Example the Ferghana Valley Irrigation District

Looking particularly at the Ferghana Valley, in the past, different strategies have been used to facilitate adaptation to seasonal fluctuations. Early on, Soviet Engineers started linking the main

tributaries with smaller tributaries of the Syr Darya through main canals [90–92]. Later on, water security was increased through the construction of small reservoirs for capturing winter flows of tributaries [16,17]. Finally, with the increase of irrigated areas in small tributaries within upstream Kyrgyzstan, pump stations were constructed to lift water from main canals towards small tributaries [15,93]. Hence, within the Ferghana Valley, a meshed system was constructed which allowed switching from the main water source to an alternative water source and winter flow on tributaries as well as main stem was captured. Therefore, water security within the Ferghana Valley was achieved through tapping from alternative water sources through additional infrastructure (duplication) and storing winter flow.

4.2. Current Water Security Approaches

After independence from the Soviet Union, whenever possible, all states tried and are still trying to find solutions for becoming independent from each other. These solutions are based on capturing current unused winter flow or through duplication of access infrastructure for the exploration of alternative water sources. Dukhovny [94] highlights that "Uzbekistan is striving for almost full satisfaction of its demand for additional water through releases from the Andijan reservoir and, partially, through construction of in-stream reservoirs".

Within the Ferghana Valley irrigation district, Uzbekistan constructed the Rezaksay reservoir (0.3 km^3) between the North Ferghana and the Big Namangan Canals and the Markaziy (Central) reservoir (0.35 km^3) along the Big Andijan Canal to store unused winter flow of Toktogul. Different riparian states are also trying to attempt water security through duplication of access infrastructure and shifting to alternative sources. Uzbekistan plans additional pump stations from the North Ferghana to the Big Namangan Canal to compensate for the inoperative diversion structure for the Big Namangan Canal in Kyrgyzstan. In addition, Uzbekistan plans new pump stations for utilizing ground water in the Ferghana province, here the aim is to compensate for less water received along smaller tributaries (key informant from BVO Syr Darya, January 2014). Still within the Ferghana Valley irrigation district, Tajikistan first started to negotiate water allocation issues regarding Big Ferghana Canal with Uzbekistan through issue linkages with the Kayrakum reservoir. More recently, Tajikistan started to divert water from the Isfara tributary directly into the tail-end part of the Big Ferghana Canal which is within its territory. Hence, although water allocations between Tajikistan and Uzbekistan were negotiated, Tajikistan was still not able to receive its water share on the Big Ferghana Canal. As consequence of the recent Tajik strategy, Uzbekistan's irrigated areas in the downstream Isfara tributary became more water insecure [15].

In the late 1990s, within the Midstream irrigation district, Uzbekistan anticipated to use the flood spills towards Arnasai Lake for irrigation [82,95]. Hence, Uzbekistan anticipated to making use of an existing "reservoir" to facilitate alternative water supply or duplication to existing canal infrastructure. More recently, Uzbekistan started to construct the Sardova reservoir (1.0 km^3) along the South Golodnyesteppe canal (key informant from BVO Syr Darya, January 2014). The reservoir will enable Uzbekistan to secure winter flow below the Kayrakum reservoir. Within the Downstream irrigation district, Kazakhstan built the Koksarai reservoir (3.0 km^3) below Chardara, and has planned two additional reservoirs for flood protection and to store unused winter flow (Figure 3). Regarding alternative water supply and duplication, Kazakhstan made use of its existing Chardara reservoir and constructed pump-stations towards the Dustlik canal to reduce its dependence on transboundary infrastructure.

So far, no alternative sources or duplication seem to be anticipated for the Kazakh part of the Chakir irrigation district. However, Dukhovny *et al.* [88] mentions that Kazakhstan is planning the expansion of its irrigated area to 98 thousand ha, with a total withdrawal of 1140 Mm^3/year. To secure the additional water needs Kazakhstan might consider a similar approach as taken in the Mid-stream and Downstream irrigation districts and might attempt to reduce dependence on transboundary infrastructure. The potential source, could be the Chirchik directly, since, 0.75 km^3/year of its flow generation is within Kazakhstan [58].

Figure 3. New reservoirs in the Syr Darya. (Source: Based on information compiled through GIS maps, as well as key informer BVO Syr Darya).

4.3. Short Discussion: Downstream Countries Increasing their Indirect Water Security

The two downstream riparian states, Uzbekistan and Kazakhstan, which were negatively affected by the operation of Toktogul within irrigation districts which depended to a larger extent on the main stem (Ferghana Valley, Midstream and Downstream) developed similar strategies regarding water security. Both are creating water storage within their territories for not having to depend on the Toktogul or Kayrakum reservoirs operation. With the creation of additional storage, the basin's downstream riparian states avoid having to negotiate summer operations and therefore paying for electricity from Toktogul. Within the Downstream irrigation district the reservoir has multiple functions; storing winter flows for flood mitigation and securing irrigation needs during the summer. However, water to the Koksarai reservoir has to be pumped. Overall, the creation of capacity to store winter flow not only reduces the dependence on other riparian states, but also decreased the bargaining power of upstream states. Given that off-season flows were already allocated within the closed Syr Darya basin, the creation of national storage, particularly in the midstream country Uzbekistan, might off-set the

existing but not anymore operationalized riparian states allocations to downstream states. In addition, the additional storage within the midstream and downstream countries (Uzbekistan and Kazakhstan) might put into question the water delivery to the Northern Aral Sea in Kazakhstan.

The creation of access to alternative water resources such as groundwater resources within the Uzbek part or the diversion of the transboundary tributary (Isfara) within the Tajik part of the Ferghana Valley irrigation district highlights the dividing up of the transboundary irrigation district according to national boundaries. Similarly, the creation of a pump station along the Chardara reservoir for supplying the Kazakh part of the Dustlik canal highlights the merging of parts of the former Midstream and Downstream irrigation districts along national boundaries. Hence, the identified water security solutions rely on national water security solutions, rather than on transboundary solutions. The implication is that although pumping costs such as on the Chardara might be economically higher, and the diversion of the STT might be more unstable due to seasonality, these solutions might provide more stability and reliability compared to the past transboundary water supply solutions.

Overall, these new water security solutions for water shortages are building on past security approaches practiced within Soviet Central Asia. However, these new solutions focus primary on national water security. While these are technical solutions to water shortages, it is questionable whether the water bureaucracy can safeguard the availability of water resources for their users.

5. Surveillance and Guards–Irrigation Bureaucracy (Example Ferghana Province)

While the previous section focused on poly-centers within the basin and on more passive security measures, here the focus turns to the meso-level, the Ferghana Province, and direct security measures, such as water metering devices, surveillance and guards. As mentioned in the introduction, here a historic approach is taken by looking at long term trends [96] (1978 to 2010) of the water supply control side of the irrigation department of Ferghana Province. Therefore it is first necessary to highlight the changes on the demand side during the Soviet period and after independence.

5.1. Geographic Background to Ferghana Province

Ferghana Province is located within the Uzbek part of the Ferghana Valley. The province occupies 6800 km^2 and consists of fifteen districts, four major cities and has a total population of about three million. The province borders Kyrgyzstan to the south-east, Tajikistan to its western side and two Uzbek provinces Andijan and Namangan to the east and north respectively. The province has access to different water sources, the Syr Darya, the Big Ferghana Canal (BFC)-diverting water from the Naryn (controlled by Toktogul reservoir in upstream Kyrgyzstan), Karadarya (controlled by Andijan Reservoir operated by Uzbekistan), the South Ferghana Canal (SFC) (taking water directly from the Andijan Reservoir) and the Big Andijan Canal (BAC) (also diverting water from the Naryn), as well as five Smaller Transboundary Tributaries (STTs): Kuvasai, Isfayramsai, Shakhirmadansai, Sokh and Isfara (from east to west), which all, with the exception of the Kuvasai, intersect with either the SFC or BFC [14]. On all main canals and small tributaries Ferghana Province is at the tail-end. With independence, the water situation for Ferghana Province was aggravated on the main canals BFC and BAC as well as some STTs (Figure 4).

Before independence, within Ferghana Province the irrigated area increased from 285,000 ha in 1969 up to 368,300 ha in 1988. After independence in 1991, the irrigated area first declined, but

stabilized at about 361,000 ha from 2006 onwards. According to Bucknall *et al*. [97] about one third of the irrigated area in the province, 115,000 ha, is supplied via pumps and pump stations (lift). Recently Wegerich *et al.* [93] showed that 151,000 ha are supplied via pump stations and of these 69,000 ha have a lift of over 50 meters. About one third of these pump stations can be classified as transboundary pump stations, which were constructed to mitigate upstream expansion in transboundary tributaries [93].

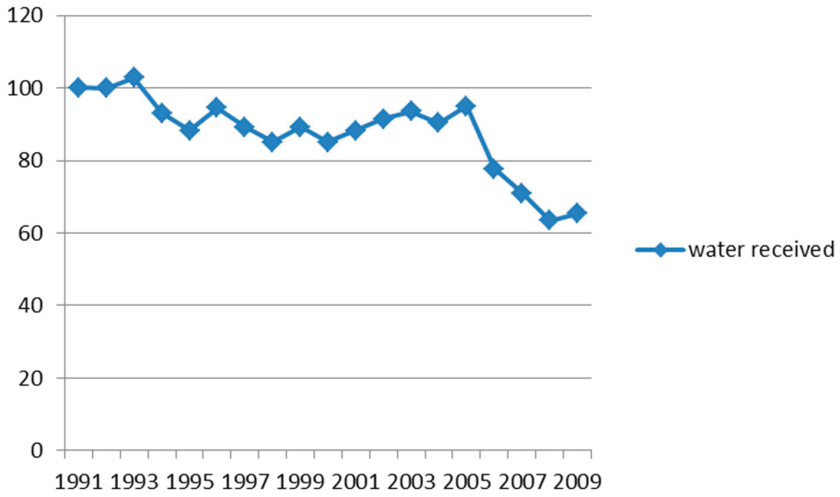

Figure 4. Total water received and utilized in Ferghana Province from 1991 to 2009 (deviation from 1991), (Source: compiled from data of the irrigation department of Ferghana Province).

5.2. Demand Side Changes-Farming Units and Crops

During the Soviet period, agricultural production was organized in crop specialized state owned large scale collective farms, varying in sizes between 2000 and 8000 ha. Within Ferghana Province were a total of 120 collective farms in 1975, which changed to 162 by 1991. During the 1990s, collective farms were transformed into semi-cooperative farms, with an average size of 2000 to 3000 ha. Within Ferghana Province a total of 164 semi-cooperative farms were registered. Although already in 1992 the law on peasant farms [98] (peasant/dehkan farms) was issued, privatization did not kick off until 2001, based on a new law concerning farms in 1998 [99]. Within the province, the number of private farms rose from about 3000 in 2000 to below 26,000 in 2007. In 2009, a Presidential Decree [100] on farm optimization was issued, which led to decrease in the number of private farms. Already prior to the Presidential Decree [100], the number of private farms dropped again in Ferghana Province. The total number was below 12,000 in 2010 (Figure 5).

Usually, when reference is made to the Uzbek SSR and its agricultural production during the Soviet period, cotton monoculture and alfalfa are mentioned. It is also argued that because of state planning the Uzbek SSR increased its irrigated area for further expanding its cotton monoculture [91,101]. The data of Ferghana Province shows that from 1978 the increases of irrigated area did not lead to an increase of the area under cotton cultivation, the area under cotton even decreased. According to Anderson [102] after the cotton scandal in the 1980s and to soften the social conditions the Uzbek SSR Leader (Nishonov) asked

permission to reduce the cotton quota for Uzbekistan. Consequently, the area under cotton decreased further in the Ferghana Province from 196,000 ha (56 percent) in 1987 to 164,000 (46 percent) in 1990.

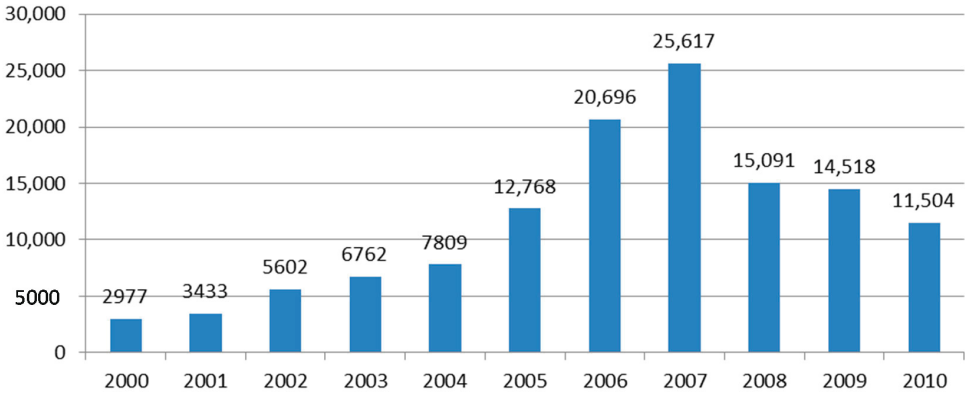

Figure 5. Dynamics of private farms in Ferghana Province 2000–2010 (total numbers).

5.3. Current Water Security Approaches Focusing on the Demand Side

After independence, Uzbekistan shifted to a policy of food self-sufficiency and therefore expanded the area under wheat cultivation. Although usually emphasized as food security policy, one could argue that the food security policy was in fact a water security policy. Within Ferghana Province winter wheat was grown from 1995 onwards. In the period from 1995 to 2010, the area allocated to cotton decreased from 36% to about 30% and the area allocated to winter wheat increased from 0% in 1994 to 31% in 2010 (Figure 6). Within Ferghana Province, winter wheat has mainly replaced alfalfa. Although winter wheat would imply less water demand during the summer season, farmers utilize the period between harvest and sowing to grow a second crop [103,104]. Recent studies have shown that the ratio of second crops after winter wheat is between 60% and 80% within Ferghana province [105]. Given the large ratio of second crops the potential for water savings is reduced (Figure 7).

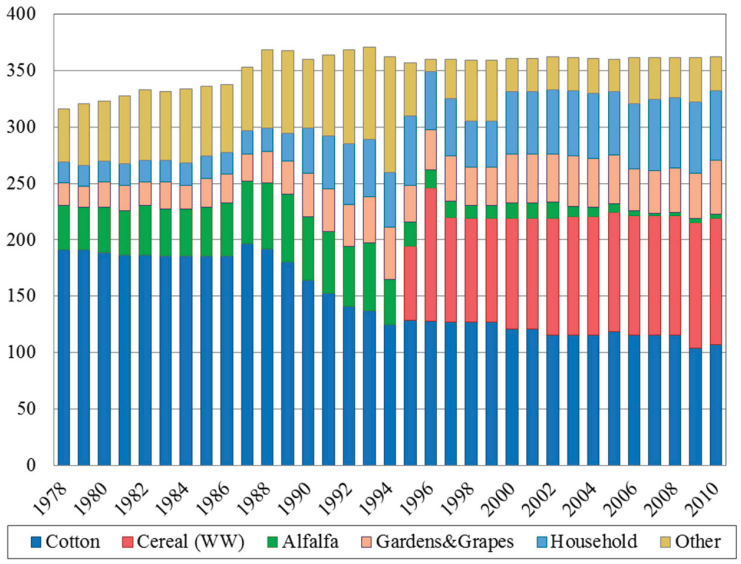

Figure 6. Changes of cropping patters 1978 to 2010 (1,000 ha).

Being concerned about the fragmentation of former collective farms and based on international recommendations, the Cabinet of Ministers of the Republic of Uzbekistan approved the Procedure for organizing Water User Associations (WUAs) in 2002 [106]. Within Ferghana Province, the Integrated Water Resources Management project, funded by the Swiss Agency for Development and Cooperation (SDC), established WUAs along the SFC and Shakhirmadansai STT. By 2011, Ferghana Province had 119 WUAs. WUAs have been mainly established on the territory of the former semi-cooperative farms (with the exception in the donor funded project). Because of the difference in numbers, it is not evident whether the process of creating WUAs was completed within the province. WUAs are newly created organizations and therefore it is questionable whether they can plan and allocate water according to requests of farmers and available water resources supplied by the irrigation department.

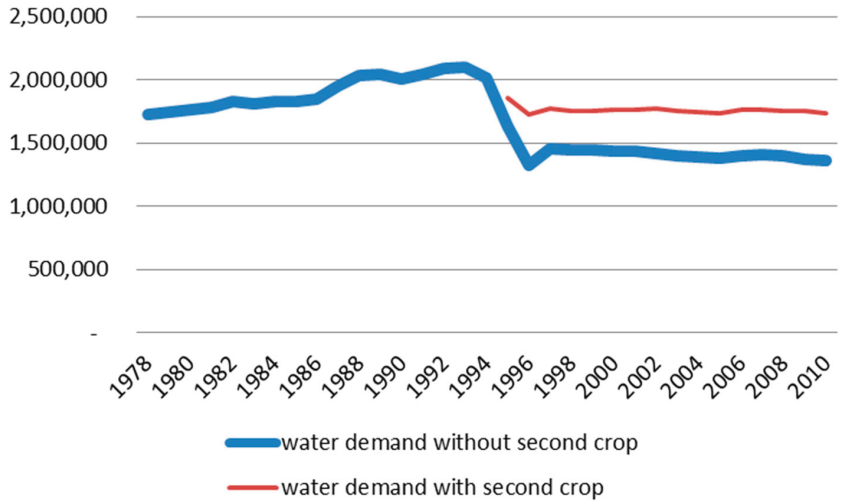

Figure 7. Irrigation norms and trends of water demand during summer season 1978 to 2010 (m^3).

5.4. Current Water Security Approaches Focusing on the Supply Side

There were few projects that focused on the water supply organizations (irrigation departments). A SDC funded project, focusing on main canal management, brought governance issues forward and therefore established a "union of canal water users" along the SFC (2002 to 2012), with less emphasis on infrastructure or finance which was demanded by the irrigation department [33]. An additional SDC project focused on main canal automation along the SFC (2005 to 2010). Towards the end of the main canal automation project key problems were raised regarding sustainability of operation and maintenance as well as capacity of irrigation departments' operating staff [107]. A Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) project (2009 to 2011) focused on GIS capacity building of water supply organizations and on creating transparency of water flow information [108]. However, also here, long term sustainability was voiced regarding staff issues. Given the early start of these different projects, one has to note that when the first SDC project started in 2002, there were no international publications on the irrigation departments in Central Asia, except some donor reports.

5.5. Supply Side Changes—The Irrigation Bureaucracy

According to Dukhovny and de Schuetter [101] "the beginning of the 1980s saw the first signs that governments were paying attention to the problems of managing the large river basins (Amu Darya and Syr Darya) in Central Asia". During the 1980–1985 period "more than 70 rubles (US$ 45 in 1980, which converts to US$ 137 buying power in 2014) per irrigated hectare were annually allocated to water management organizations. Accordingly fixed assets at the inter-farm level increased by 36%, the number of service staff at the inter-farm level increased by 20%, the number of inter-farm irrigation networks equipped with water-measuring structures increased by 93% and water-distributing structures increased by 94%" [101]. After independence, the situation changed. Thurman [109] highlighted limiting factors of the irrigation departments for controlling water supply to the users, "very low salaries, small operational budgets, and very little equipment". Wegerich [110,111] looking at staffing and logistics of the irrigation department of Khorezm province argued that the past procedure of controlling off-takes from main canals was not anymore possible. Other studies have highlighted that the 1997 merger between the Ministry of Agriculture and the Ministry of Water Resources, led to a downgrading of the Water Ministry as merely dependent department [70,111–115].

5.6. Case Study the Ferghana Province Irrigation Department

At the time of basin closure in the beginning of the 1980s, the Ferghana Province Irrigation Department controlled water supply through hydroposts (measuring infrastructure within main canal and at off-take level) and flexible guarding (motor bikes and staff) (Figure 8). The long-term trend up to 1997 shows that the number of staff of the irrigation department was set on expansion. This is similar to the trend with the number of hydroposts, showing a rapid increase from the mid-1980s to 1990, and a slowing increase up to 1997. Flexible guarding through motor bikes expanded rapidly in 1983 and 1984, and stabilized at a lower level in 1987. However, after independence in 1991, motor bikes were not mentioned anywhere within the annual reports of the irrigation department.

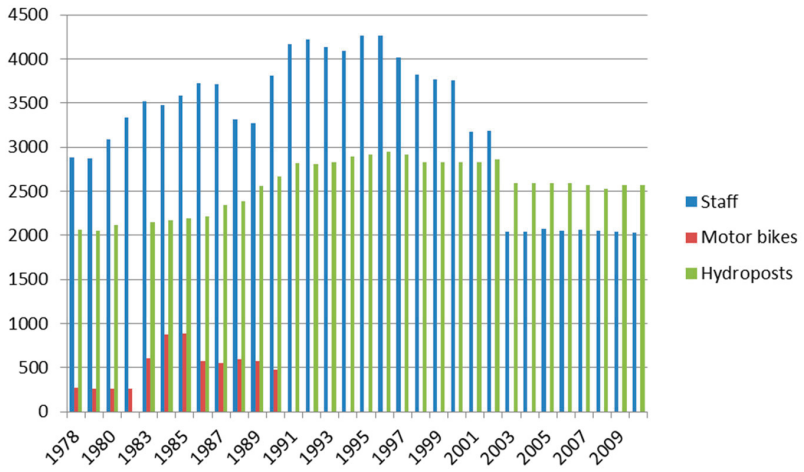

Figure 8. Dynamics of supply side control-surveillance and guards in Ferghana Province (total numbers).

While the most staff increases of the irrigation department can be attributed to the construction of pump stations during the 1980s [93], the rapid fall of staff numbers in 1988 to 89 and 1992 to 93 appear to be due to wider social, nationalistic and economic changes[116–118]. In 1997 the Ministry of Water Resources merged with the Ministry of Agriculture 1997 marks the turning point for trigging a downward trend regarding staffing as well as hydroposts. In 2003, a main canal dispatch center was created in Ferghana Valley, which as consequence had a reduction of the number of staff as well as the reported number of hydroposts under the Ferghana Province Irrigation Department.

As mentioned before, there has been a major increase of operation and maintenance from 1980s onwards [101]. Until 1985, expenditure on operation and maintenance appears to have been nearly stable with rapid increases during the period from 1986 to 1990 (Figure 9). Hence, it appears that the Soviet Union put high emphasis on water supply security and control of water supply. During the economic crisis which followed independence, the operation and maintenance expenditure decreased rapidly, and regained the level of 1986 only by 1996. However, with the merger between the two Ministries operation and maintenance as well as rehabilitation expenditure declined to insignificance. Although from 1996 onwards the Uzbek Gross Domestic Product (GDP) started to increase again [119], this increase has not triggered a reinvestment in the Ferghana Province Irrigation Department.

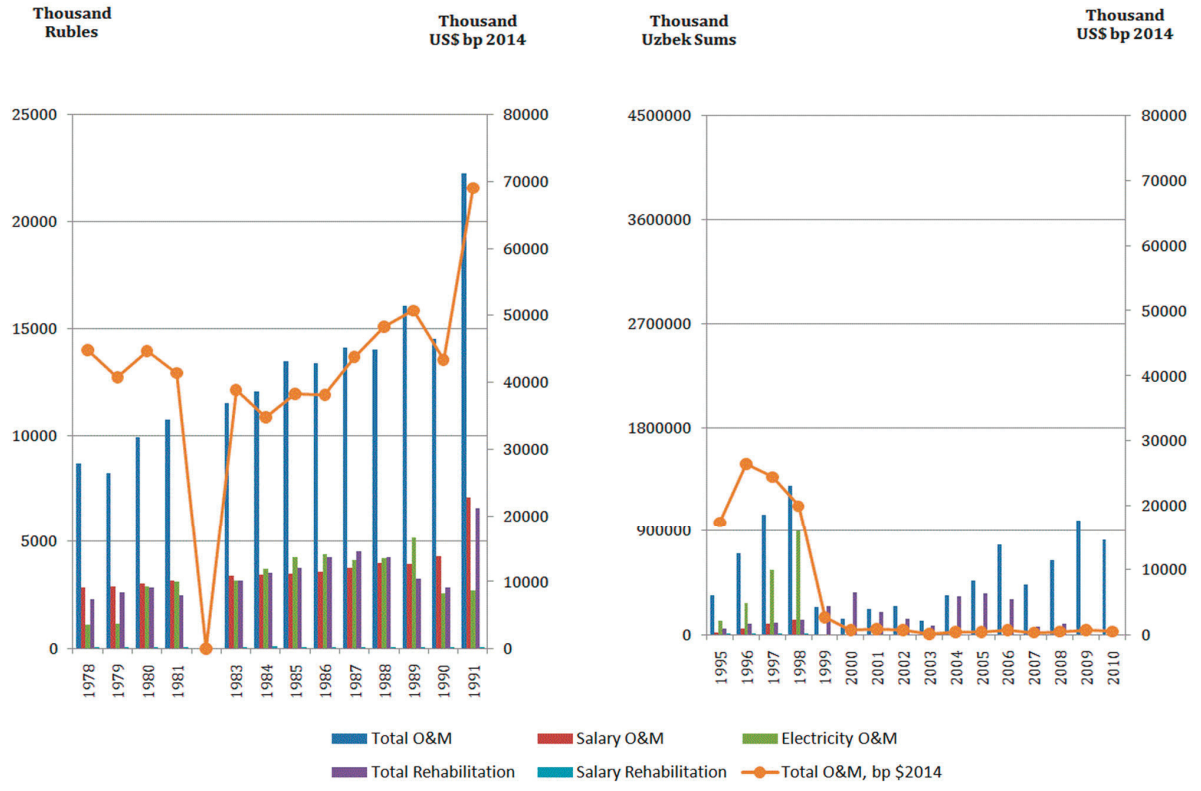

Figure 9. Expenditure for Operation and Maintenance and Rehabilitation (in 1,000 Soviet Union Rubles for the period 1978–1991 and 1,000 Uzbek Sums for the period 1995–2010, the secondary axis is in 1,000 USD buying power as of 2014).

The disappearance of motor bikes and the increasing total number of staff and hydroposts could suggest that there was a shift from flexible to static (staff being posted at the hydroposts directly) water supply control after independence up to 1997. However, the declined salary level combined with an overall rising staff number suggest that full-time employment within the irrigation department might not have guaranteed livelihood security. Kandiyoti mentions that often employees were only formally employed but in fact did not receive salaries [120]. Therefore, it is questionable whether after independence surveillance and guarding continued. Similarly, the decreasing expenditure on maintenance after independence suggests that the number of functioning hydroposts has declined, but that dysfunctional hydroposts are still recorded.

5.7. Short Discussion: Losing Direct Water Security

During the time of the Soviet Union, rising water demands (due to expansion as well as change in cropping patterns) triggered an adaptation process of the irrigation department. During this period there was an increase of water supply control noticeable with the increasing numbers of staff, hydroposts and motorbikes. More funding was allocated to operation and maintenance as well as rehabilitation of water supply infrastructure. After independence water demand continued to increase; however this was not anymore matched with increases in water supply or an increased water supply security. Therefore, there appears to be an apparent mismatch between official figures of water supplied and evidence of water utilized.

An adaptation process for the new situation came only in 1995 with the introduction of winter wheat and therefore an assumed reduction of overall water demand. The adaptation of crops cannot only be interpreted as a response to a decrease of water supply, but possibly also as a political attempt to avoid strengthening the organizational capacity of the irrigation department, through increases of finances and logistics. In this respect, the merger between the two ministries, which followed the introduction of winter wheat, could be interpreted not only in terms of budget savings, but also that the solution for water supply insecurity was seen through controlling agriculture rather than water supply. However, given that about 60% to 80% of winter wheat area is utilized for second crops, this attempt did not reduce the need for water supply security solutions but aggravated the situation further, since the second crop diversity demands more irregular irrigation compared to mono cropping of cotton. The merger triggered further budget and staff cuts within the irrigation department and therefore the water supply security was lost completely. With the implementation of land reforms, the need for water supply security would have increased significantly. However, there is no evidence that water supply security has been strengthened.

Looking at past projects (SDC and GIZ) it is evident that the first focus on governance through "union of canal water users" was misplaced, since water supply security was not possible. Looking at the total operation and maintenance budget of the irrigation department, it is also evident that canal automation would have added an additional burden, which was unlikely to be sustainable. Looking at the salary of irrigation department staff, it is also evident that staff after having gained additional knowledge would look for other job opportunities. Therefore, unfortunately, these projects appear to have been too ambitious and possibly too premature, assuming that the irrigation department would have an existing capacity of supply security. It appears that these projects focused on a piecemeal

approach, omitting key questions of capacity, and mainly not considering that irrigation departments are government organizations, and the potential of donor influence on these established bureaucracies could be limited if it is single focused and project based.

Given the deteriorating position of funding and therefore capacity of the irrigation department to control and the negative aspects for its staff, regarding salary, it is evident that the diversity and power inequities of WUAs along main canals might increase. Given the lack of capacity to control, it is likely that the foremost rising inequity will be based on the location along main canals. In addition, Platonov *et al* [105] have highlighted that within Ferghana Valley the inequity depends also on the off-take infrastructure. The implication is, that irrigated area which rely on more costly infrastructure (such as pump stations), which are operated and maintained by the irrigation department, are less likely to be able to produce profitable second crops. In addition, there is already evidence, that the lack of control on the main canal level has negative effects and has increased power disparities within WUAs. Mukhamedova and Wegerich [45] highlight how water scarcities are inequitably distributed within WUAs and affecting mainly the most vulnerable part of the communities, kitchen gardens in villages.

Although this second section only presented the case of the Uzbek Ferghana Province, it is assumed that Ferghana Province is not only representative regarding its budget limitations for Uzbekistan, but also for other riparian states (Kazakhstan, Kyrgyzstan and Tajikistan). However, Uzbekistan and Tajikistan compared to Kazakhstan and Kyrgyzstan are late implementers of land reforms as well as lifting slowly the restrictions on agricultural production. Therefore, in Uzbekistan, agricultural water demand and the subsequent need for increasing water supply has likely expanded more slowly compared to its neighboring countries.

6. Discussion Linking Irrigation District to Meso-Level Water Security

The first section demonstrated that after independence in 1991, water supply security was high on the agenda with building resilience through additional or alternative water supply sources (from existing national reservoirs, groundwater sources, or small transboundary tributaries) as well as duplication of or less reliance on critical infrastructure (through the construction of smaller reservoirs within the country, pump-stations or diversion canals for small transboundary rivers). The second section showed for the Uzbek Ferghana Province that less attention was paid to surveillance and guards in the irrigation schemes, and that consequently the irrigation department lost its capacity to secure water supply to the water users. Hence, water supply security appears to focus on technical solutions (new infrastructure), while old and deteriorating infrastructure as well as operational sustainability of the water departments are neglected. Possibly, the focus on capturing more water and setting up additional supply lines might postpone the strengthening of existing organizations. Consequently, the chosen approach might secure more water resources, but possibly will not lead to more equitable water distribution within irrigation systems. Furthermore, there appears to be little reflection of the government on past infrastructure strategies and subsequent consequences for the irrigation departments. The past strategy on duplication (switching sources through the construction of pump stations) proved to be very costly and financially unsustainable for the Ferghana Province irrigation department [93]. Although these strategies could imply more water security through avoidance of transboundary dependence, the short and long term financial sustainability is questionable.

Although these strategies increase national water security they also increase the energy demand for supporting irrigated agriculture. Therefore these strategies move the water-energy nexus from the basin to the national or provincial level.

The different water security approaches after independence were: (1) introduction of winter wheat in 1995 (adjusting demand); (2) creation of WUAs in 2002 (direct security approach at the local level) and (3) infrastructure projects starting by 2010 (indirect security approach at the meso-level). None of these initiatives directly addressed the main water supply organizations. Hence, there was no direct security approach at the meso-level. It is likely that this was a conscious decision. Possibly for Uzbekistan the merger between the Ministry of Water Resources and the Ministry of Agriculture decreased the focus on water supply organizations. A direct security approach would have increased the potential power of the former Water Resources Ministry. However, since globally public irrigation management is viewed negatively and as having failed [26], it is likely that also from the donor side strengthening the irrigation departments was off the agenda. At least, looking at Kyrgyzstan, the donor community attempted to circumvent irrigation departments by establishing top-down "bottom-up" WUA federations for replacing irrigation departments (as in the case of World Bank projects) [121]. Nevertheless, it is not evident, how WUA federations would be able to take over managerial responsibility or would have the capacities to cover operation and maintenance costs, especially looking at the high past expenditures of the Ferghana Province Irrigation Department.

7. Conclusions

So far, neither polycentric water management nor water supply organizations (irrigation departments) have received broad international attention within the Syr Darya Basin. Instead, so far the main focus has been on the creation of WUAs at the local level and basin management at the international level. The implication is that there is a widening gap regarding promoted and actual water security approaches as well as a missing link, which in the past have been the province irrigation departments. Hence, by looking at meso-level water security ("irrigation districts" as well as irrigation departments) the paper has attempted to close an important gap of the current water security focus in the Syr Darya Basin.

Irrigation departments are negatively viewed as public sector organizations, and are perceived as having failed to adapt to wider socio-political or environmental changes [26]. However, the long term data on the Ferghana Province highlighted that the irrigation department was capable of adapting by increasing staffing and mobility as well as creating resilience through new infrastructure during the Soviet period. Only after independence and due to the economic crisis, the administrative changes (merger between the two Ministries) and possibly the exposure to the global "neo-liberal" donor community focusing on water user governance, led to the decline of the irrigation department's capacity. There is great potential for the current discourse on water security and the water, energy and food nexus to refocus attention to the challenges of existing water supply organizations. However, at least based on suggestions from some of the global literature [4,6], the essential element of water supply security, have been either taken for granted or overlooked. Similar, although Sadoff *et al.* [28] puts key emphasis on water supply organizations, the mentioned "institutional tripod" (water users, states and markets) might imply an emphasis on governance, without strengthening the capacity of the water supply

organizations first. The findings of the case study demonstrated the loss of technical and organizational water control and therefore the loss of the capacity of the irrigation department. The implication of not strengthening the water supply organizations are already evident; increased inequality of water distribution along the main canals, which negatively affects water distribution within WUAs. Given the already identified weaknesses of governance due to the diversity and power inequities of users, these inequities could further increase.

As indicated by our analysis the weakest link for water security is the public administrations, it is therefore essential to finally engage with the water bureaucracy. This calls for a comprehensive analysis regarding past and current internal as well as external challenges for the water bureaucracy for enabling its revitalization on key water security challenges. This call for revitalizing the water bureaucracy challenges the neo-liberal paradigm. Given that the bureaucracy is a public administration, a revitalization will not be possible in a piecemeal approach of donor sponsored "projects" (like the SDC and GIZ project mentioned in the case study) but instead calls for a long-term approach for reinvestment and modernization and therefore strengthening the public administration.

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Author Contributions

Kai Wegerich developed the initial and final versions of the framework, analyzed the data, organized the systematic discussion and led the drafting process of the manuscript. He incorporated the study incorporating the contributions from co-authors as well as from reviewers at TU Berlin and IWMI. Daniel Van Rooijen provided substantial comments on the initial framework section as well as the initial version of the manuscript. Ilkhom Soliev and Nozilakhon Mukhamedova contributed by providing their expertise and insights on the study area as well as on transboundary arrangements as well as local level land and water reforms.

Conflicts of Interest

The authors declare no conflict of interest.

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4 Dynamics of Water Reallocation and Cost Implications in the Transboundary Setting of Ferghana Province

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Dynamics of water reallocation and costs implication in the transboundry setting of Ferghana Province

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Abstract

While in the international literature the water sharing within the Syr Darya basin are widely portrayed as Uzbekistan benefitting most from past agreements, here dynamics of water allocations within small transboundary tributaries within the Ferghana Province show the opposite. The case study highlights that water allocation for Uzbekistan within the tributaries decreased over the years. Uzbekistan's approach to compensate for the reduced allocations through other water sources had large long term cost implications for irrigated agriculture as well as the Irrigation Bureaucracy. The paper contributes to the international debate on benefit sharing in transboundary rivers. The paper highlights that costs should be incorporated into the benefit sharing approach, and therefore to focus on benefit sharing alone is misguiding riparian states. Furthermore, the paper raises the need for re-evaluating benefits, since perceptions on potential benefits change over time.

Keywords: transboundary benefit sharing, long-term costs, irrigation bureaucracy, pump- stations, Central Asia

1. Introduction

The earlier mutual gains (Fisher and Ury 1981; Sewell and Utton 1986) and the currently promoted benefit sharing approach (Sadoff and Grey 2002, 2005; Philips et al. 2006) can be seen as powerful tool to achieve better agreements with greater incentives for riparians in a transboundary setting. However, while these approaches mainly focus on benefits, the term "costs" is not emphasized as much as the term "benefits" within these approaches, studies highlighting long term costs estimates of cooperation are relatively rare (Soliev et al. 2015; Tarlock and Wouters 2007; Hensengerth et al. 2011; Dombrowsky 2007). Here, a long term study on Uzbekistan attempts to highlight costs of cooperation, by looking at compensation mechanisms of upstream irrigated area expansion.

Uzbekistan is known for its large pump-stations lifting (shortened as lift) water to large scale irrigation systems particularly lifting water from the Amu Darya to the provinces of Surkhandarya (66 % of total irrigated area), Kashkardarya (80 %) and Bukhara (100%) (Bucknall et al. 2003, Annexes: 19) as well as the high costs induced by pump-stations. About "70% of the Ministry of Agriculture and Water Resources (MAWR) budget is allocated to electricity used by pumping stations" (Khamraev 2011: 80). While some of these irrigation schemes can be simply attributed to the hydraulic mission of the Soviet Union, like Kashkardarya and Surkhandarya (Saiko and Zonn 2000), others can be attributed to the expansion of irrigated area in upstream territories of Uzbekistan, such as Bukhara (Wegerich 2014). However, little attention has been paid so far, to the expansion of lift irrigation due to the expansion of irrigated area in transboundary settings (Pak et al. 2014). Hence, externally induced lift irrigation systems to compensate for upstream irrigation expansion in other riparian states remain unexplored.

Here the focus is on Ferghana Province within the Ferghana Valley. Through archival research on agreements and correspondence on small transboundary tributaries (STTs) (from 1960s up to 2013) as well as annual reports of the Ferghana Province Water Management Department (WMD) (from 1978 up to 2010) and interviews with key informers, the link between upstream expansion of the irrigated area in Kyrgyzstan and the increase of pump-stations and the consequences for existing irrigation system in downstream Ferghana Province as well as for the irrigation bureaucracy will be established.

The paper continues with a brief conceptual overview outlining the status of the research on the benefit sharing approach. The next section provides a short geographic description of Ferghana Province, its water resources and a short historical background to the expansion of pump-stations in the Uzbek Soviet Socialistic Republic (SSR). This is followed by a historical overview of negotiations on water sharing in small transboundary tributaries (STTs) and development of lift irrigation in the province structured according to decades. The next section looks into the influence of these developments on the irrigation bureaucracy of the Ferghana Province WMD. In the discussion section linkages of the case study to the wider water discourses and political environment prevalent in Central Asia established. Finally, the paper concludes with linking the case study back to the theory, highlighting the need for considering costs within the benefit sharing approach and the need for re-evaluating benefits, since perceptions on potential benefits change over time.

2. Conceptual framework: Sharing water resources idealistic and realistic approach

Literature on the hydraulic mission is mainly emphasized through World Bank lending for irrigation development as well as the expansion of the irrigated area (Faures et al. 2007). Implicit is, that the irrigation bureaucracy expanded during the hydraulic mission as well (Molle et al. 2009). While the focus of the hydraulic mission has either a global or national perspective, little attention has been paid to externally induced drivers for the hydraulic mission or parts of it, such as transboundary factors (i.e. the hydraulic mission

of link-canals in the Indus Basin in Pakistan) (Wescoat et al. 2000). The implication is that transboundary cooperation or coping strategies could be part of the hydraulic mission. Although the examples might be small in number, little attention has been paid so far linking the expansion of the irrigation bureaucracy or irrigation technologies to transboundary settings.

While coping with water stress is a complex subject on its own (e.g. Ohlsson and Turton 1999), coping with water stress in shared water resources gets complicated further depending on the specifics of relationship between riparian countries (e.g. Zeitoun and Warner 2006). Here, the specific focus is on what would make a strategy of a downstream riparian in response to upstream irrigation expansion sustainable. There are several schools of thought: one with prevailing legal perspective focusing on the role of bilateral or multi-lateral agreements between riparians and following the fundamental principles of international water law (more idealistic approach) (e.g. Eckstein 2014a, 2014b), one with the prevailing focus on searching for incentives (economic, social, environmental, political) for better cooperation (more realistic approach) (e.g. Sadoff and Grey 2002, 2005; Philips et al. 2006; Dombrowsky 2007;), and others with a different degree of combined focus on these two aspects (Soliev et al. 2015; Hensengerth et al. 2011; Dombrowsky 2009, Pak and Wegerich 2014). In the first case, the studies direct their attention more to the questions related to how it should be so that the sharing is equitable and reasonable, while in the second one, scholars mostly try to understand and explain why actors behave in a certain way, why they conclude agreements and might or might not implement them, and what happens when there is no agreement.

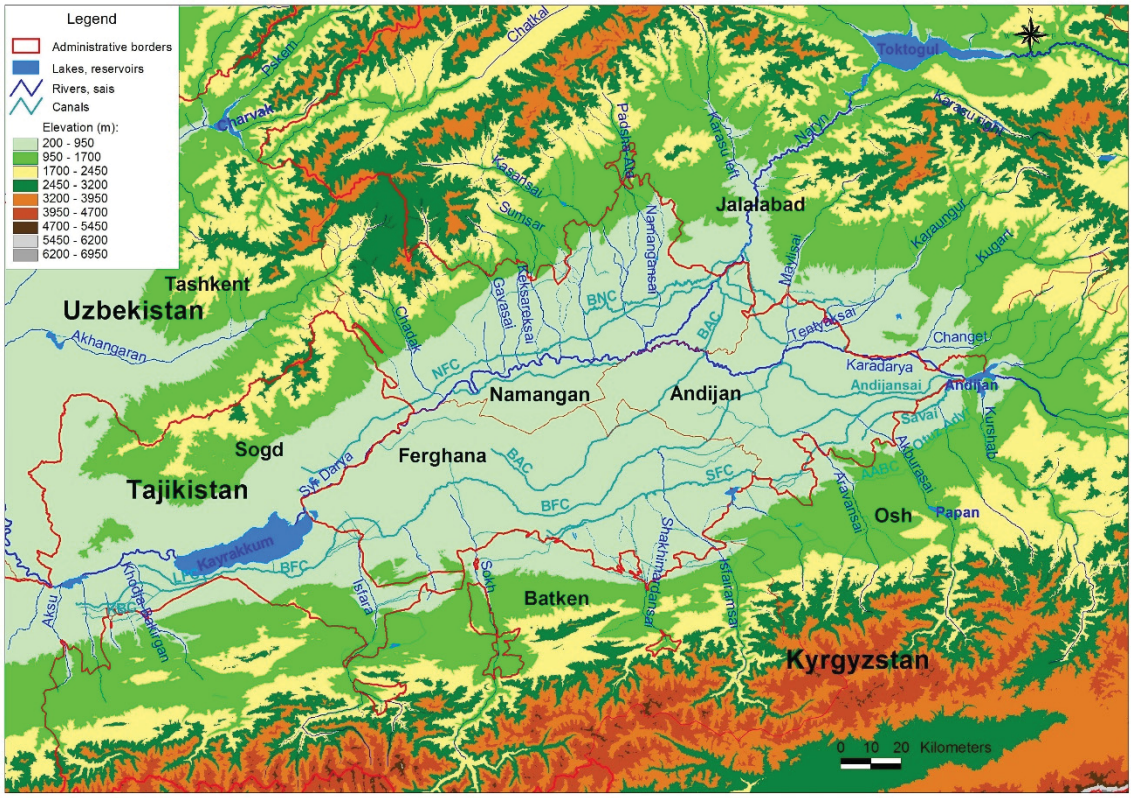
The literature indicates that in the long run the practices of international water management is slowly moving towards the idealistic approach as more parties join the international water conventions (e.g. 1997 United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses) (Eckstein 2014a, 2014b). Similarly, bilateral and multilateral agreements are discussed in more sophisticated detail and becoming more common (e.g. most recent, the 2015 Nile Agreement). The studies with combined focus look at incentives compatibility of past, existing or potential future agreements and arrangements (e.g. Dombrowsky 2009). In this regard, the mutual gains or benefit sharing approaches have been seen as powerful tools to achieve better agreements with greater incentives for riparians in a transboundary setting.

However, actors have to make decisions based on the available information: agreements in place, estimated costs and benefits of available options for coping with unforeseen changes in circumstances or for concluding new agreements if needed. Complexity of resource systems in management of shared water resources often makes it difficult to estimate costs and benefits in longer periods. Hence, focus on short-term benefits might lead to negligence of costs in the long run. In addition, it is likely that taking a longer time horizon circumstances and factors influencing the perception on benefits change. Hence, what was perceived beneficial at one point might not be perceived as such in the long run (Hartman 2012).

3. Background to Ferghana Province

Ferghana Province is located within the Uzbek part of the Ferghana Valley (Figure 1). The province occupies 6,800 km^2 and consists of fifteen districts, four major cities and has a total population of about three million. The province borders Kyrgyzstan to the south-east, Tajikistan to its western side and two Uzbek provinces Andijan and Namangan to the east and north respectively.

During the late 1930s and early 1940s within the Ferghana Valley the Soviet water engineers "embarked on the construction of several of the major canals in the Ferghana Valley that would link together the various oases" (Weinthal 2002, p. 84). The main idea of linking the small rivers and the main tributaries of the Syr Darya was to direct water from relatively abundant sources to the water-short systems and establish a flexible and controllable irrigation system that permitted more uniform water allocation. The Soviet engineers created a fan (radial) irrigation system (Benjaminovich & Tersitskiy, 1975). Consequently, the Ferghana Province has access to different water sources, the Syr Darya, the Big Ferghana canal (BFC) - diverting water from the Naryn (controlled by Toktogul reservoir in upstream Kyrgyzstan), Karadarya (controlled by Andijan Reservoir operated by Uzbekistan), the South Ferghana canal (SFC) (taking water directly from the Andijan Reservoir) and the Big Andijan canal (BAC) (also diverting water from the Naryn), as well as five smaller transboundary tributaries (STTs): Kuvasai, Isfayramsai, Shakhirmadansai, Sokh and Isfara (from east to west), which all, with the exception of the Kuvasai, intersect with either the SFC or BFC (Wegerich et al 2012a). On all main canals and small tributaries Ferghana Province is at the tail-end.



AABC - Aravan-Akbura Canal, BAC - Big Andijan Canal, BFC - Big Ferghana Canal, BNC - Big Namangan Canal, KBC - Khodja-Bakirgan Canal, NFC - North Ferghana Canal, SFC - South Ferghana

Figure 1: The Ferghana Valley

Up to the mid 1980s the Uzbek SSR was engaged in the hydraulic mission by increasing the irrigated area up to 4.2 million ha. Particularly within Ferghana Province the irrigated area increased up to 1988 to 368,300 ha. After independence the irrigated area has stabilized at about 361,000 ha from 2006 onwards. According to Bucknall et al. (2005:19) about one third of the irrigated area in the province, 115,000 ha, is supplied via pumps and pump-stations. Bucknall et al. focusing on the economics of agriculture does not look at the reason for the construction of pump stations. Therefore it appears that all of the irrigated area was part of the internal hydraulic mission within the former Uzbek SSR or even Uzbekistan. However, Pak et al. (2014) show for the Isfara river that the Tajik and Uzbek SSRs constructed pump-stations to compensate water allocation to existing irrigated areas within their territories from other water sources (the Syr Darya and BFC) for the expansion of irrigated area in the upstream Kyrgyz SSR in the 1970s. Hence, there is an indication that not all pump-stations were constructed because of the hydraulic mission within the former Uzbek SSR. Wegerich (2014) shows for the years 1978 to 2010 the changes of irrigated area and the increases of lift irrigation (Figure 2). The data show that the increase of irrigated area diverges from the increase of irrigated area supplied by pump-stations. Hence, the data suggest that to some extent existing irrigated area was supplied by pump-stations and therefore, must have shifted the water source, from direct diversion from a small river or canal to water supply via pump-stations from either a different canal or directly from the Syr Darya.

Figure 2: Irrigated area and increase of lift irrigation 1978 to 2010 (ha)

Wegerich (2014) suggests that the increases of pump-stations might be related to rising competition within a closing basin, including transboundary riparian states as well as provinces. However, Wegerich does not provide details or show evidence. Soliev et al. (2015) show the expansion plans of the riparian states within the Ferghana Valley. While they are mainly focusing on benefit sharing of the water resources, pastures and shared reservoirs, compensation through pump-stations is not addressed.

4. Case study – upstream expansion and compensation mechanism in Ferghana Province

A significant upstream expansion influencing the water resources available to Ferghana Province was expected already in the beginning of the 1960s. In 1961, Moscow decided that the Kyrgyz SSR, in line with compensation for the lands given for the Toktogul reservoir, was allowed to expand its irrigated area by 15,000 ha in the Burgandy massif through regulation of the Sokh STT (Memorandum 1986). To expand the irrigated area within the Sokh basin the construction of the Sokh reservoir was anticipated. The Sokh reservoir was reiterated during the Andijan reservoir negotiations in 1962-65 with plans of building the Left-shore Kampyr-Ravat (LSKR) canal to deliver water to the Burgandy massive. The LSKR was to irrigate 8,000 ha in the Kyrgyz part of the Burgandy massive and 15,900 ha in the Uzbek part (Protocol 1965).

With the expected increased capacities of water storage through the Toktogul reservoir as well as through a number of relatively smaller projects (Andijan, Karkidon, Sokh, Papan, Tortgul reservoirs, Left-shore Naryn canal, Right-shore Kampyr-Ravat canal, LSKR canal, etc.) it was anticipated to expand the irrigated area within the Ferghana Valley and beyond (Soliev et al. 2015).

4.1 The 1970s

In 1970, the Ministry of Agriculture and the Ministry of Water resources of the Union of Soviet Socialistic Republics (USSR) introduced new 15 year plans (1971 to 85) on irrigation and drainage expansion (Order 1970) (table 1). The plans were significantly higher and more costly than the plans for the past 15 years (from 15.57 billion Soviet Union Rubels (SUR) to 110-115 billion SUR). Taking into consideration their water shares, the republics could submit project proposals for irrigation expansion. The anticipated higher costs of the expansion was due to "the acquisition of more complicated zones of lands – those requiring lifting water with pump-stations and those with higher salinity or prone to salinization requiring additional preparatory works." (Annex 1 to Order 1970: p.10)

Table 1: The status and plans of the Soviet land reclamation activities as of 1970 for the USSR (thousand ha)

Commissioning additional capacities, thousand ha	Reported period			Total in 1956-1970	Planned period	
	1956-1960 (actual)	1961-1965 (actual)	1966-1970 (expected)		1971-1985	Average for a 5 year step
Irrigation of lands	753	1,290	1,434	3,477	10,000	3,300
Drainage of lands	1,731	2,899	3,816	8,446	22,000	7,200
Irrigation of pastures	57,922	44,077	32,938	134,937	60,000 (10 years)	30,000

Source: Order (1970)

The 1970 Water Law of the USSR introduced the Schemes of complex use of water resources for river basins. The first complex Scheme for the Syr Darya basin was approved till 1985 by the State Expert Commission of the State Planning Committee (Gosplan) USSR with some corrections and recommendations for further studies

(Resolution 1973). The Scheme of 1971 (Protocol 1972) identified the maximum irrigation expansion limits for the riparian republics with anticipated expansion within the Ferghana Valley by about 30% up to 1990 (table 2). Priorities for expansion were seen under the systems of the BFC, the Andijan reservoir and STTs on the right and left shores of the Syr Darya basin.

Table 2: Plan for irrigation expansion in the Ferghana Valley according to the Syr Darya Scheme of 1971 (thousand ha)

Planning zone	Irrigated in 1965	Irrigated in 1970	Planned commissioning of the irrigated lands			
			in 1975	in 1980	in 1985	in 1990
Ferghana Valley	1028	1058	1168	1230	1270	1382

Source: Protocol (1972: p.6)

Resolution (1973) of the State Expert Commission of the Gosplan USSR approved the expansion of the irrigated area within the Kyrgyz SSR within the range of 60,000 (minimum) -90,000 ha (maximum), including 49,000 ha within the Ferghana Valley. Later, several high priority proposals on irrigation expansion were submitted for internal consideration (Reference Certificate 1974b). Relevant extracts of anticipated projects on the STTs shared with Ferghana Province are presented in table 3. It is assumed that these projects were part of the response to the Order (1970) and the Schemes being developed at the time.

Table 3: Extracts of the proposal of the Ministry of Water resources of the Kyrgyz SSR

Name of a system/object	Expansion (minimum), ha	Expansion (maximum), ha
Batken Valley	9,000	9,000
Arka massive	6,000	6,000
Isfayramsai-Shakhimardansai STTs	6,500	6,500
Burgandy massive	-	8,000
Total	21,500	29,500

Source: Report (1973)

Overall at least six (about 66,000 ha) out of the nine proposed projects (of about 137,000 ha) were along shared transboundary water resources. The downstream implications were not taken into account by the proposals. Instead, the evidence suggests that the Osh Province WMD was increasingly concerned that by the time the Toktogul reservoir was completed, benefiting mainly Uzbek SSR interests, the designs of the LSKR canal and Sokh reservoir were still not approved (Stage Questions 1981). One of the internal documents of the Osh Province WMD makes a note: “to take water from all the other rivers if the Uzbek SSR does not construct the LSKR canal” (Reference Certificate 1974a).

In 1976, the Kyrgyz SSR received additional funds from Moscow as compensation for the Toktogul reservoir (Resolution 1977) and the Burgandy massive continued to be developed. The Andijan reservoir was completed in 1978, but the LSKR canal was still not approved. Correspondence from 1979 in Ferghana Province show that the Kyrgyz SSR rapidly increased water use from the Sokh STT diverting to the Burgandy massive and from the Isfara STT diverting to the Tortgul reservoir. To mitigate the consequences,

the Ferghana Province WMD sent several letters to the Kyrgyz side, and requested the Uzbek government and Moscow to mediate the situation, and requested assistance of the Andijan Province WMD to ensure delivery of water from the water sources entering from Andijan Province (see section 1980s).

There is no data on expansion plans of the Uzbek SSR within the Ferghana Valley. However, as the plans on most of the infrastructure targeting the Uzbek part of the Valley were agreed and decided before this period (Toktogul, Andijan, Kayrakkum, Karkidon, Kasansai reservoirs, a number of canals), it can be assumed that the Uzbek SSR was still in the expansion mode according to its past plans. The irrigated area of Ferghana Province rose from about 285,000 ha in 1969 to 320,000 in 1979. In the same period the irrigated area under lift increased from about 16,000 ha (with lift beyond 50m of 1,000 ha) to 71,000 ha (with lift beyond 50m of 33,000 ha). Given that the Kyrgyz SSR was planning to expand its irrigated area – the Uzbek SSR must at least have developed plans for securing water supply to existing irrigated areas for compensating upstream expansion. Data provided by the Ferghana Province WMD shows that during this period five pump-stations (uplift >50 m) with the total capacity to irrigate about 16,000 ha were constructed with the purpose to compensate for transboundary upstream expansion (table 4; figure 3).

The WMD also highlighted that during this period six pump-stations (uplift >50 m) were constructed due to internal intensification. It was explained that internal intensification implied that existing irrigation systems which would have received canal water, came under stress because of new diversions from main canals to areas which were affected by transboundary expansion. Hence, pumps stations were constructed either on collectors, main canals, or small rivers to provide alternative water supply. All of the pump stations constructed for internal intensification were in the eastern part of Ferghana Province and within the tail-end area of the Isfayramsai and Shakhirmadansai STTs and SFC. Given that the new water sources are mainly collectors for Ferghana district as well as the SFC and BFC for the other districts the data verifies that the construction mainly compensated the upstream expansion within the Kyrgyz SSR .

4.2. The 1980s

With the discussions on basin closure in the 1980s two key complaints from the Kyrgyz SSR continued, these were the delays of construction of 1) the LSKR canal and 2) the Sokh reservoir by the Uzbek SSR. In 1980 new water sharing arrangements regarding the STTs in the Ferghana Valley, developed by the design institute Sredazgiprovodkhlopok, were agreed (Protocol 1980). In the Protocol (1980) is was noted that the new arrangement took into account both the new storage capacities and the two non-constructed projects. However, the Kyrgyz SSR expressed its disagreement over the shares (table 5), particularly, claiming that 1) the non-built LSKR canal and 2) the feeding of the Isfayramsai and Shakhimardansai STTs from the SFC (9 m^3/s) and of the Sokh STT from the BFC (12 m^3/s) were not taken into account. As a response Sredazgiprovodkhlopok explained that although the new arrangement was developed based on the proportional allocation principle for the lands of all republics and that the Kyrgyz SSR was entitled to satisfy its needs first and only the remaining runoff could be used by the Uzbek SSR (Note to Protocol 1980; Response Certificate on the Note to Protocol 1980).

Table 4: Pump-stations to compensate upstream expansion during the 1970s

#	Pump station name	No. of Aggre-gates	Type of pump	Power KWH	Max capacity (м3/sec)	Lift (meters)	Year of con-struction	Irrigation area (ha)	Source	Number of staff required
					Direct transboundary compensation					
					Oltiariq district					
1	KFK-SSHK 1	4	20 NDS	3200	3.2	50	1974	2850	BFC	9
2	Chuvrindi-2 (Usmonhujaev 2)	2	300 D-90	500	0.6	67	1970	500	BFC	5
					Quvasoy district					
3	Isfayram-Shohimardon	5	28 M12x2	12500	4.8	180	1974	5000	SFMC	11
						50	1972	3600	SFMC	
					Rishton distict					
4	KFK-Rishton-1	3	300D-90	750	0.9	66	1979	460	BFC	5
					Uzbekistan district					
5	KFK-Sokh	4	22 NDS	9100	4.4	170	1975	3640	BFC	11
	TOTAL	18		26050	13.9			16050		41
					Internal intensification due to compensation					
					Ferghana district					
1	Oq tom	2	300D-90	500	0.6	55	1970	280	Collector	7
2	Hangiz 1	2	300D-90	500	0.6	50	1971	280	Collector	7
3	Hangiz 2	3	300D-90	750	0.9	55	1971	250	Collector	7
4	Yangiobog	2	200 D-70	110	0.5	50	1970	320	BFC	6
					Qushtepa district					
5	Loyson	2	20 NDS	900	1.6	68	1970	750	Collector	7
						50	1972	3600	SFMC	
					Quva district					
6	Buston (Ohunbobo ev)	3	D-1250-65 300 D-90 12 NDS	750	0.75	72	1970	156	SFMC	7
					Quvasoy district					
7	Pahta uchun	4	10 NMK x2	2520	1	156	1976	750	Sai	9
	TOTAL	18		26050	13.9			6386		50

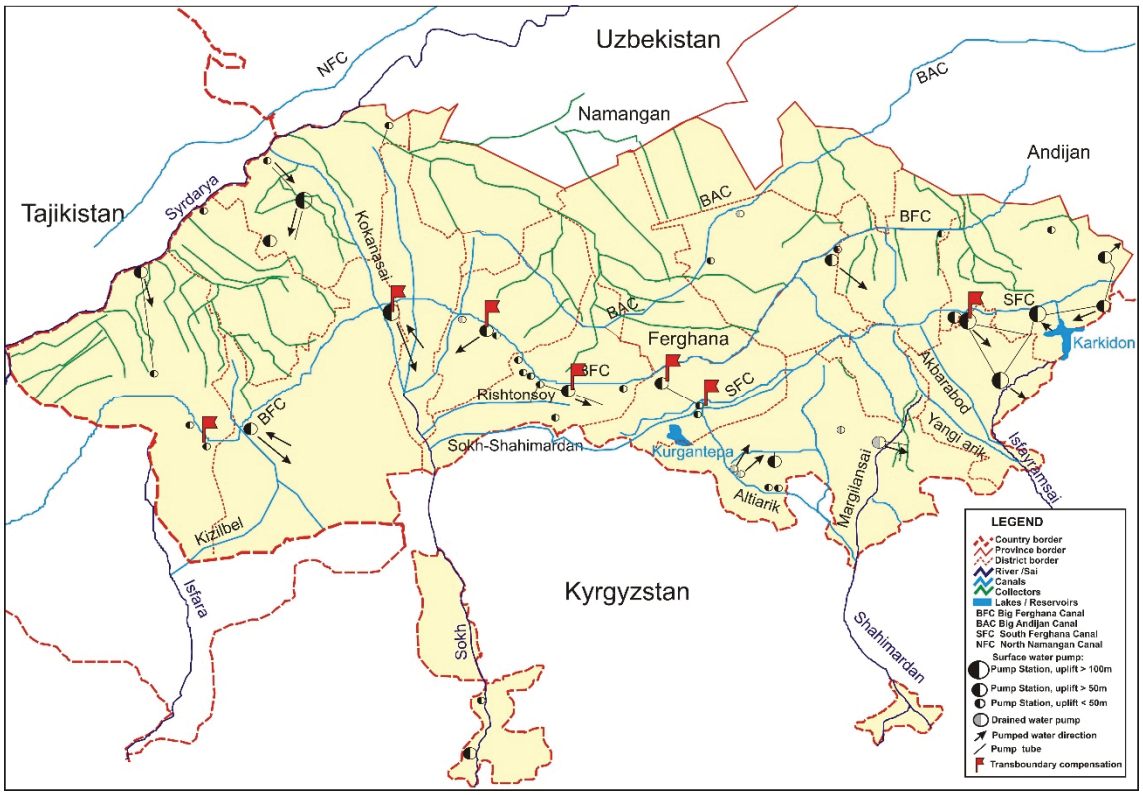


Figure 3: Pump-stations in Ferghana Province by the end of the 1970s

Table 5: Allocation of the water resources of the small rivers in the Ferghana Valley

River, canal	Runoff under 90% supply level, mln. m^3	Water resources used for irrigation, mln. m^3	Share of the Uzbek SSR, mln. m^3	Share of the Kyrgyz SSR, mln. m^3	Share of the Uzbek SSR, %	Share of the Kyrgyz SSR, %
Right-shore systems of the Karadarya river (Right-shore Kampyr-Ravat canal)	-	193	-	193		
Savai canal	-	227	183	44		
South Ferghana Canal	-	800	768	32		
Akburasai	521	426	76	350	18	82
Aravansai	154	137	32	105	23	77
Isfayramsai	566	448	312	136	70	30
Shakhimardansai	275	186	136	50	73	27
Sokh	1140	1079	988	91	90	10
Isfara*	375	323	27	120	8	37
Maylisai	158	66	12	54	18	82
Padshaata with Chartaksai	222	241	155	86	64	36
Kasansai without tributaries	184	235	216	19	92	8

* including 176 mln. m^3 (55% of the flow) for the irrigation needs of the Tajik SSR[1]
Source: Protocol (1980)

By the end of 1980, the Ferghana Valley had 1,227,000 ha of irrigated lands (Corrective Note to the Refined Scheme 1983). The expansion maximum was set at 1,341,000 ha (table 6). Already at that time the lion's share of the irrigated area was utilizing water

[1] Pak et al. (2014) highlights disagreement of the Tajik SSR on the allocation on Isfara.

from the Karadarya and STTs. The proposed additional increase led to further negotiations and clarifications on the lands and water allocation shares.

Table 6: Irrigated lands and maximum expansion in the Ferghana Valley as of 1980, thousand ha

Republic	As of end of 1980			Expansion			At the closed level of the basin (maximum)		
	Total	Main stem Naryn-Syr Darya	Karadarya and STTs	Total	Main stem Naryn-Syr Darya	Karadarya and STTs	Total	Main stem Naryn-Syr Darya	Karadarya and STTs
Kyrgyz SSR	255.5	6.5	249.0	60.7	16.0	44.7	316.2	22.5	293.7
Tajik SSR	124.8	78.6	46.2	19.1	19.1	-	143.9	97.7	46.2
Uzbek SSR	847.0	379.8	467.2	34.5	30.0	4.5	881.5	409.8	471.7
TOTAL	1,227.3	464.9	762.4	114.3	65.1	49.2	1,341.6	530	811.6

Source: Corrective Note to the Refined Scheme of the Syr Darya (1983: p. 4-5)

The Protocol (1980) recommended to the Ministries of Water resources of the republics to jointly develop decadal allocation of waters on annual basis, which led to further downscaling to the province level. To implement the Protocol, the Ferghana and Osh Province WMDs concluded an Agreement (1980), considering the construction of the the Sokh reservoir and LSKR canal as well as water allocation from the Karkidon reservoir and the four STTs: Isfara, Sokh, Shakhimardan and Isfayramsai. After the agreement, the construction works of the Sokh reservoir on the Sokh STT were initiated (Decision 1980; Protocol 1988).

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Nevertheless, despite the new arrangements, the Kyrgyz SSR kept demanding an increase on almost all STTs. The Osh Province WMD claimed that they received less water than agreed (Protocol 1980) in five cases out of twelve (three canals and nine STTs) and requested an increase in seven STTs, including five STTs where the agreed terms were implemented (Reference Certificate 1981). The republics reached a new agreement on the shares from the Sokh STT in 1989, which increased the share of the Kyrgyz SSR from 10% or 91 million m^3 as per Protocol (1980) to 23% or 296.5 mln. m^3.

In the period from 1980 to 1989 the irrigated area in Ferghana Province increased to 367,000 ha and the irrigated area under lift increased to 136,000 ha (with total area under lift beyond 50m reaching 68,000 ha). All pump-stations classified as transboundary compensation which were constructed during this period were within the basins of the Sokh STT (Bogdod, Rishton, Uzbekistan districts) and Isfara STT (Beshariq district) (table 7, figure 4). All pump-stations classified as internal intensification were constructed within the Sokh basin, with the exception of Toshloq district. Therefore, not considering the exception, the data suggests that the pump-stations classified as intensification could be classified as transboundary as well.

Table 7: Pump-stations to compensate upstream expansion during the 1980s

#	Pump station name	No. of Agg-regates	Type of pump	Power KWH	Max (м3/sec)	Lift (meters)	Year of con-struction	Irrigation area/ha	Source	Number of staff required
				Direct transboundary compensation						
				Bogdod district						
1	Bogdod-Rishton 2	2	20 D 6	1600	4.2	90	1987	2500	1 level	6
		1	24 NDS	2400		90	1987	2500	1 level	
2	Bogdod	9	10 NMKx2	5670	2.25	160	1980	1430	BFC	11
3	Chuvrindi-2 (Usmonhujaev 2)	2	300 D-90	500	0.6	67	1970	500	BFC	5
				Beshariq district						
4	Rapkon-1	4	14 D-6	2520	1	200	1980	800	BFC	11
		1	1600/90	630	0.4	200	1980		BFC	
		5	10NMKx 2	3150	1	200	1980		BFC	
				Rishton district						
5	Buloqbos hi 1	6	14D6	3780	3.6	125	1989	4480	BFC	12
		5	20 D6	4000	2	80				
6	KFK-Rishton-2	2	350D-90	320	0.7	280	1983	214	Dutir ariq	5
				Uzbekistan district						
7	Ganiobod-1	3	20 D 6	1890	1.2	85	1980	700	BFC	8
8	Nursuh	3	22 NDS	4450	3.3	90	1984	800	BFC	9
	TOTAL	43		30910	20.25			13924		67
				Internal intensification as a result of compensation						
				Oltariq district						
1	Oltiariq 2 (Ohunboboev-2)	3	200 D-90	300	0.5	50	1983	250	BAC	5
2	Lola	4	300 D 50	1260	1.2	55	1989	900	BFC	7
		2	550-D-22-A	110	1					
				Toshloq district						
3	Navbahor	4	18 NDS	1000	2.4	62	1986	1150	BFC	7
				Uzbekistan district						
4	Nursuh	3	22 NDS	4450	3.3	90	1984	800	BFC	9
	TOTAL							3100		28

Figure 4: Pump-stations in Ferghana Province by the end of the 1980s

4.3. The 1990s

The five Central Asian states signed the Almaty Agreement in 1992. Key within the agreement was to recognize the necessity for cooperation and to honor the existing pattern and principles as well as acting regulations of water allocation from the interstate sources. In 1998 the Syr Darya Framework agreement, which focused on the operation of the Toktogul reservoir, was signed between Kazakhstan, Kyrgyzstan and Uzbekistan. With independence and the financial crisis thereafter the construction works on the Sokh reservoir stopped and only the works related to the started resettlement continued (Letter 1993). It is assumed that with the inflation and crisis after independence the funds were sufficient only for these works.

In the period from 1990 to 1999 the total irrigated area dropped to 358,000 ha while the irrigated area under pump-stations increased to 146,000 ha (with lift beyond 50m of 69,000 ha). There was no pump-station constructed with uplift beyond 50 meters to compensate transboundary expansion during the 1990s. However, during this period three pump-stations were constructed which were mentioned under internal intensification (table 8, figure 5). The WMD confirmed that more water from the Isfayramsai STT was utilized after independence. Given, the overall water insecurity after independence, one could also classify these pump-stations as a consequence of transboundary insecurity, but this time based on the overall insecurity along main canals dependent on Toktogul operation.

Table 8: Pump-stations to compensate internal intensification during the 1990s

#	Pump station name	No. of Aggre-gates	Type of pump	Power KWH	Max capacity (м3/sec)	Lift (meters)	Year of con-struction	Irrigation area (ha)	Source	Number of staff required
					Quvasoy district					
1	Karamkul	2	D 1250-65	500	0.5	70	1994	320	Isfayra msai	7
2	Sharq yulduzi	3	K90-85	119	0.7	80	1990	70	Isfayra msai	5
					Ferghana district					
3	Kaptarhona	2	300D-90	500	0.6	70	1994	230	Logon canal	6
	TOTAL	7						620		18

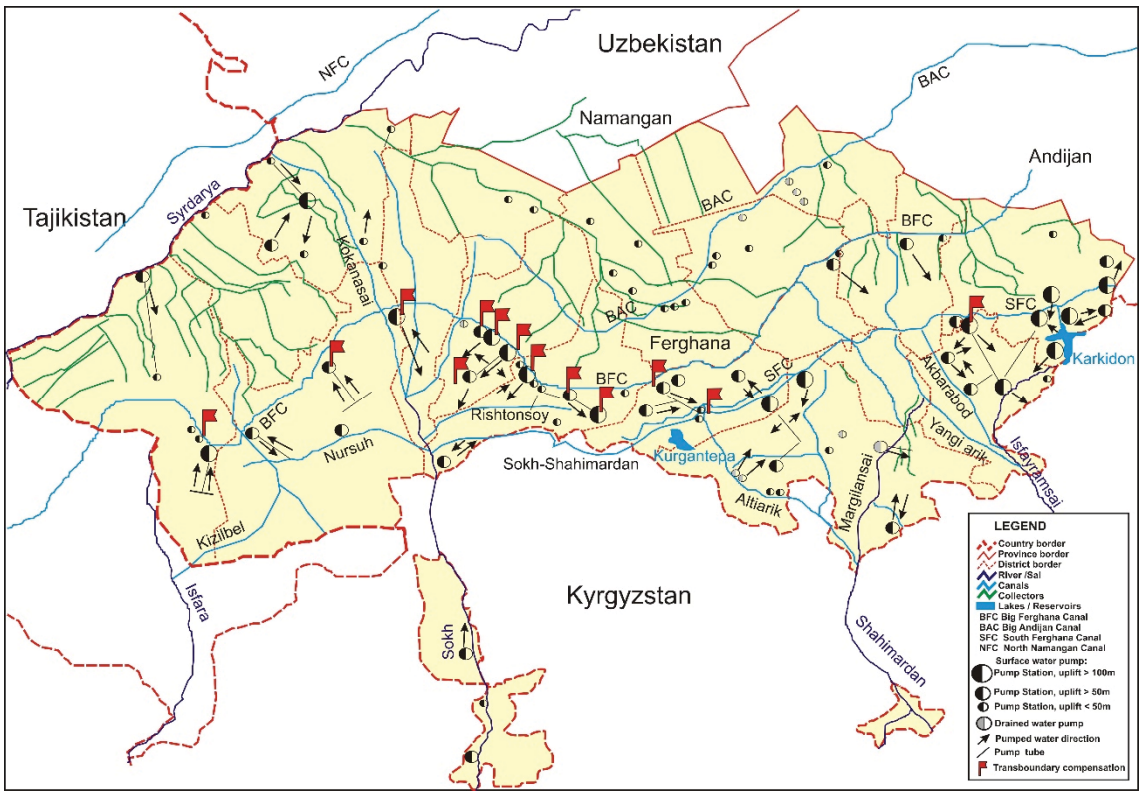

Figure 5: Pump-stations in Ferghana Province by the end of the 1990s

4.4. The 2000s

In the 2000s and with the barter energy trade established in the Syr Darya Framework agreement (1998) the incentives of the countries increased to secure more water from other sources (Wegerich et al. 2012b; Pak et al. 2014). Even though there was additional water insecurity on the main stem of the river supplying water to the BAC and BFC, in 2001 Kyrgyzstan and Uzbekistan came to an oral agreement to share three STTs (Sokh,

Shakhimardansai and Isfayramsai) on 50/50 basis. The agreement further significantly reduced the overall water share of the Ferghana Province (compare Protocol 1980; Protocol 1989). Despite the changes, in the period from 2000 to 2009 the irrigated area in Ferghana Province increased again to 362,000 ha and the irrigated area under pump-stations increased to 151,000 ha (with lift beyond 50m of 69,000 ha). There was no pump-station constructed with uplift beyond 50 meters classified to compensate transboundary expansion or as internal intensification during the 2000s.

5. Influence on the irrigation bureaucracy of Ferghana Province

After the Russian invasion of Central Asia as well as during the Soviet Union investments in irrigation development was mainly state driven (as it was also the case for other colonies). With public funded irrigation projects state water bureaucracies were created. State water bureaucracies were responsible for flood protection, hydropower generation and large-scale public irrigation (Dukhovny and de Schuetter 2011). Dukhovny and de Schuetter (2011) highlight the different periods of mechanization and industrialization of the water bureaucracy in Central Asia. The irrigation departments were not only responsible for construction but also for the operation and maintenance of the irrigation and drainage systems. While Dukhovny and de Schuetter (2011) highlight the increasing sophistication of the irrigation department, Wegerich et al. (2015) shows the expansion of the irrigation department itself by focusing on staffing and logistics for water control. More recent international publications focused on administrative reforms the restructuring of the Irrigation Departments according to hydraulic/hydrographic boundaries (Suhardiman et al. 2014; Wegerich 2015) and the introduction of Water User Associations (Zinzani 2015).

Although, the above section suggests that the details of water sharing are explicitly discussed between the riparian states, there is little information regarding the overall costs of the compensation mechanisms regarding pump-stations. While, with larger infrastructure like dams, these costs could be more easily determined (Hutchens 1999), pump-stations are absorbed within the wider budgets of the Ferghana Province WMD and there is no distinction between pump-stations which were constructed for transboundary compensation, internal intensification purposes or for opening new lands for irrigation. Hence, this section attempts to deduce the implications of the new infrastructure from the wider budget, with particular emphasis on operational (staffing and electricity) as well as maintenance and rehabilitation expenditure. To separate pump-stations constructed due to transboundary expansion and internal intensification from the total costs a categorization for estimating costs was established.[2] The estimation was consequently applied for all relevant costs of pump-stations.

[2] In the absence of detailed individual data for pump stations, a categorization was established for estimating percentages of costs from total budgets. This categorization included an age effect, the number of aggregates for individual pump stations, lift height and irrigated area. Limitation, since only the date of construction is provided here it is assumed that this marked the end of construction and the beginning of operation.

Looking at staffing within the Ferghana Province WMD the increases of staff in the 1980s can be mainly attributed to the increase of pump-stations (table 10). In the period from 1980 to 1990 the irrigated area rose from 320,000 to 367,000 ha (increase 47,000 ha; 14.7%) and the staff of the irrigation department rose from 3,083 to 3,813 (total staff) (increase 730 staff; 23.7%).

During the 1980s the total irrigated area under pump stations increased from 71,000 to 136,000 ha, with total lift beyond 50m from 33,000 to 68,000 ha. The official staff requirement for pump-stations with lift above 50 meters constructed during the 1980s was 200 staff. Of these 200 staff, 67 and 28 staff were required for pump-stations classified for transboundary compensation and for internal intensification, respectively. There has been a significant increase of pump-stations during the 1970s too. The total irrigated area under pump-stations increased from 16,000 to 71,000 ha, with total lift beyond 50m from 1,000 to 33,000 ha. The official staff requirement for the pump-stations with total lift beyond 50m alone was 153 staff, from these 41 and 50 staff were required for pump-stations classified as transboundary compensation and internal intensification respectively.

Table 9: Changes of number of staff

Year	All staff	Administrative & managerial staff	Engineers & technicians	Others	Increase of staff at pump station (above 50m lift)	Increase of staff on transbounary pump station (above 50m lift)	Increase of staff on internal intensification pump station (above 50m lift)
1970					153	41	50
1980	3083	233	1062	2021	200	67	28
1990	3813	252	1178	2507	25	0	18
2000	3761	208	1030	2731			

The WMD provides total operational costs for salary of staff as well as electricity costs for pump-stations (Figure 6). About, one third of the total costs can be allocated to pump-stations constructed to compensate for transboundary expansion and internal intensification.[3] Looking at the WMD annual budget reports, it shows that with the exception of 1984 and 1988 the salary in SUR were mainly at the increase up to 1990. Only in 1984 and 1988 there was a reduction of total staff, which seems to have also affected the staffing at pump-stations and therefore is noticeable as operational costs. Regarding costs in SUR of electricity, the operational budget shows only a decline in 1987. This decline could be attributed to the high-flow year of 1987-88 and that therefore, less water was needed for compensation within the tributaries (Keith and McKinney 1997). During the time of the Soviet Union, the costs for maintenance and rehabilitation of pump-stations increased continuously (figure 7), and by far outstripped the maintenance costs of simple canal irrigation, which were mainly de-silting.

[3] The yearly expenditures of the irrigation department either in Soviet Rubles or Uzbek Sums have been converted to US$ with annual exchange rates. To take into consideration inflation the buying power (bp) of the US$ of 2014 has been applied.

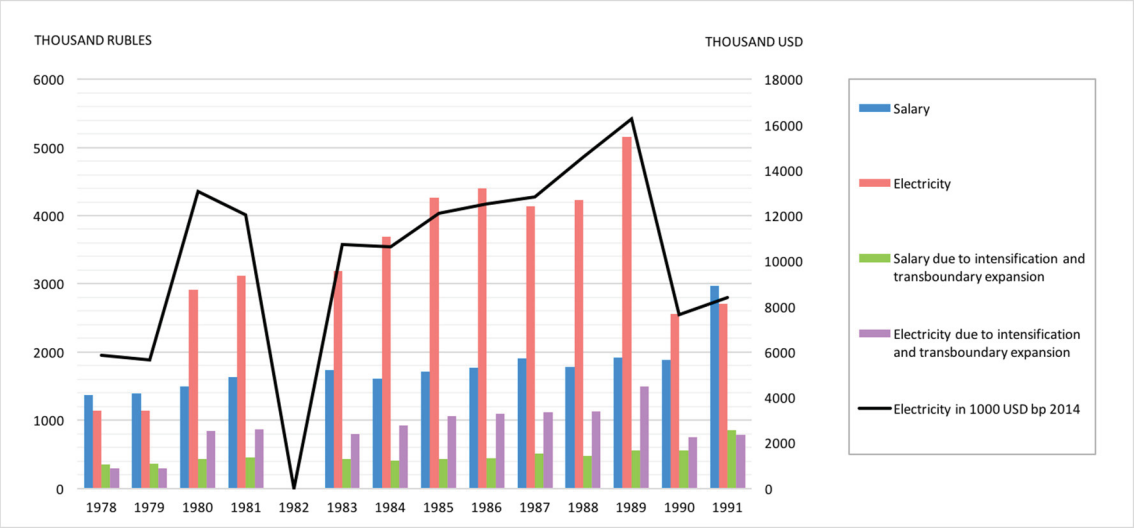

Figure 6: Operational expenditures: salary and energy for pump-stations from 1978 to 1991[4], thousand SUR

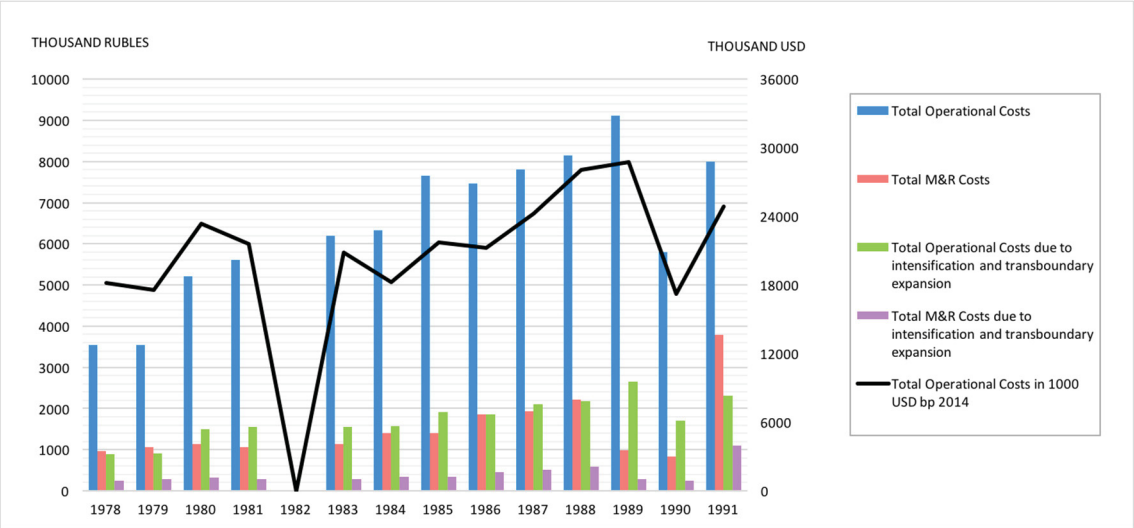

Figure 7: Operational and M&R expenditures for pump-stations from 1978 to 1991, thousand SUR

After independence in 1991, Uzbekistan continued with the Soviet Ruble and shifted to Uzbek sum coupon only after experiencing hyperinflation in 1993 and finally to Uzbek sum (UZS) in 1994 (Pomfret 2006). During this period the salary of WMD staff was reduced significantly. Only from 1996 onwards the GDP increased again (Taube and Zettelmeyer 1998). Directly after independence and up to 1995 the total number of staff of the WMD increased, however, the total salary was much below pre-independence. In 1997 the Ministry of Water merged with the Ministry of Agriculture (Wegerich 2005) and by 1998 the electricity costs of pump-stations was nearly at pre-independence level (about US$ 117/ha bp 2014). However, it appears that after the merger, the pump-stations

[4] Data for 1991 has to be treated with caution since there was already a significant increase of inflation.

were handed over to a different organisation, and therefore the total operational budget of the pump-stations disappears from the budgets of the Ferghana WMD (figure 8 & 9).

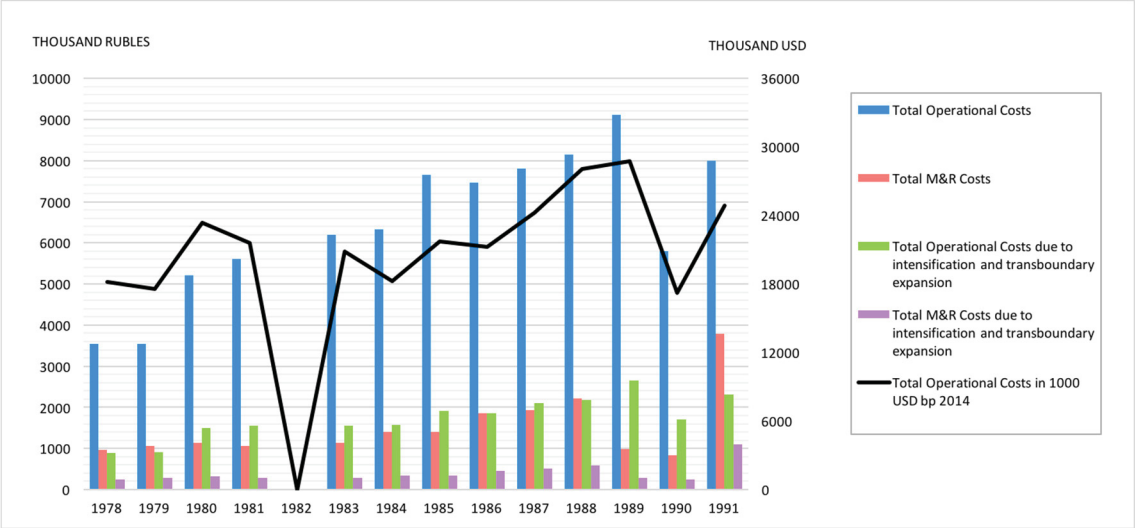

Figure 8: Operational expenditures (salary and energy) for pump-stations from 1995 to 2002, thousand UZS

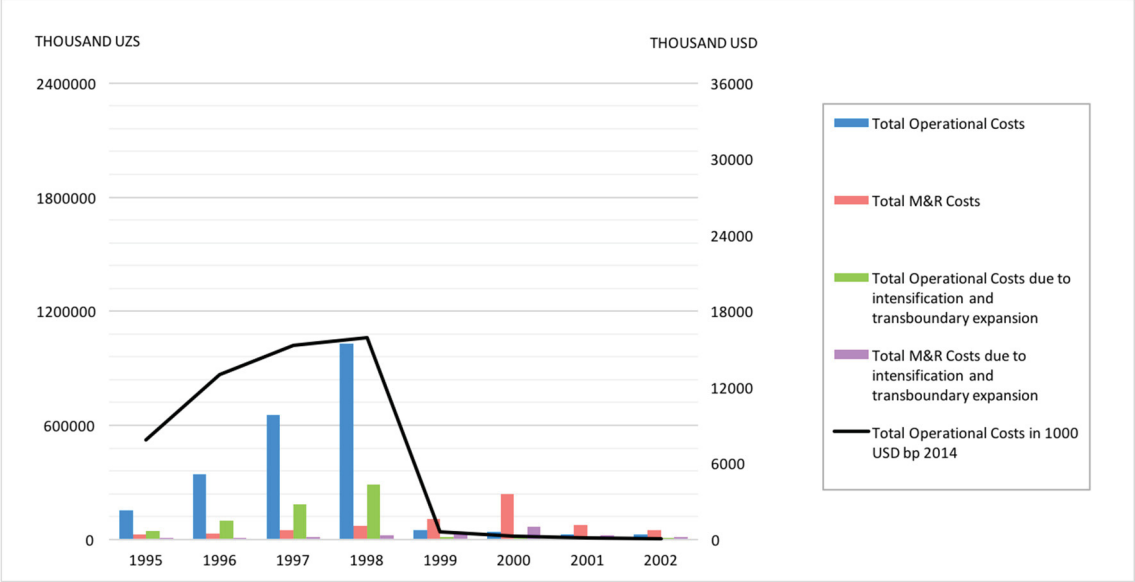

Figure 9: Operational, Maintenance and Rehabilitation expenditures for pump-stations from1995 to 2002, thousand UZS

6. Discussion

Looking at the different periods, several observations should be highlighted to understand the dynamics of development of pump-stations (table 10 and figure 10). First, since 1970s the irrigated area under pump-stations has been always on the increase with the highest increase in the 1980s. Second, the irrigated area under pump-stations has always been

greater than the total increase in irrigated area. Third, in the 1970s and 1980s the number of pump-stations constructed and irrigated area with height above 50m to compensate for upstream expansion was very significant – in the 1970s comparable to the total increase in irrigated area and in the 1980s about 30 percent of the total increase. Fourth, the evidence suggest that the pump-stations which have been classified as internal intensification could be also classified as transboundary compensation.

Table 10: Summary of irrigation expansion, including pump-stations according to decades in Ferghana Province, ha

Decades	Total irrigated area		Irrigated area under pump-stations		Irrigated area under pump-stations with height above 50m		Irrigated area under pump-stations with height above 50m, pump-stations constructed to compensate upstream expansion			
	Beginning of decade	Increase within decade	Beginning of decade	Increase within decade	Beginning of decade	Increase within decade	Beginning of decade		Increase within decade	
							Direct com-pen-sation	Due to internal intensi-fication	Direct com-pen-sation	Due to internal intensi-fication
1970s	285,000	35,000	16,000	55,000	1000	32,000	0	1000	16,050	6,386
1980s	320,000	47,000	71,000	65,000	33,000	35,000	16,050	7,386	13,924	3,100
1990s	367,000	-8,000	136,000	10,000	68,000	1000	29,974	10,486	0	620
2000s	359,000	3,000	146,000	5,000	69,000	0	29,974	11,106	0	0

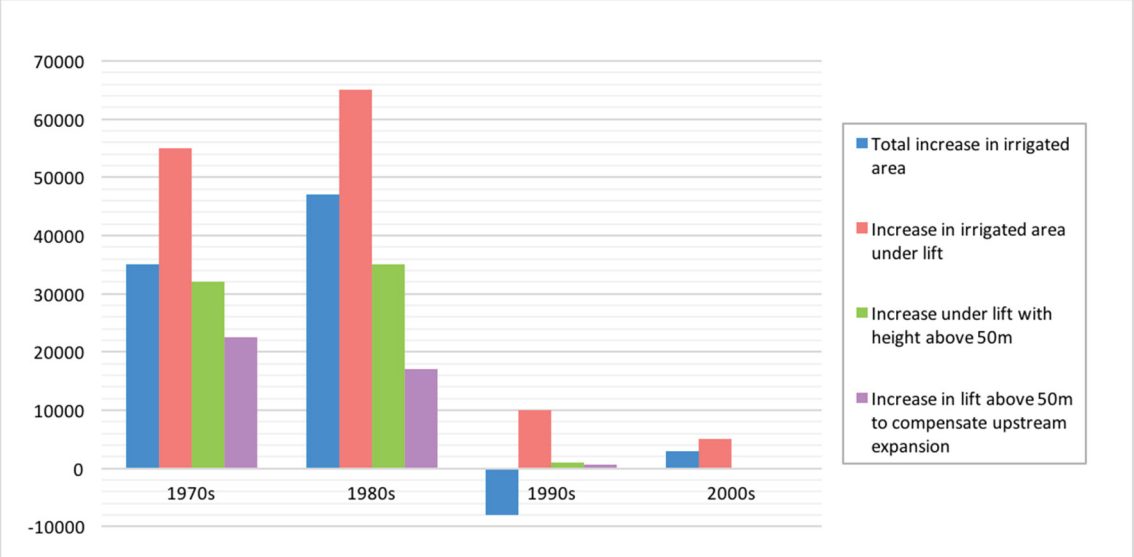

Figure 10: Comparative dynamics of increases in irrigated area, including lift in Ferghana Province according to the decades, ha

While already in the 1980s it was emphasized that the expansion of the irrigation area should be cost effective (Soliev et al. 2015), the case study on Ferghana Province highlighted that this overarching emphasis was not followed. Having stated this, the increase of lift to compensate for the expansion in upstream areas could have considered the social costs of resettlements within the Uzbek areas. Resettlements could have been regarded to be more costly, than the assumed costs of constructing lift irrigation. Although

in the construction of dams resettlement and compensation for affected populations were a significant issue in negotiations between the Uzbek and Kyrgyz SRRs, it seems that compensation for potential resettlements regarding upstream irrigation expansion within the STTs was never put on the agenda. Hence, it was possibly simply assumed that upstream expansion and therefore more water utilization should have been compensated from other sources, although more costly than the original irrigation systems. The last agreement on 50/50 water sharing and therefore the acceptance from the Uzbek side to receive less water in STTs, highlights that even today, compensation for potential upstream expansion is still not considered in negotiations. Having stated this, even the negotiations on the operation of the Toktogul have never considered compensation payments for downstream irrigated agriculture or even potential resettlements as a consequence of less water flows during the summer seasons.

Given that Uzbekistan had already experiences of the cost of construction, operation and maintenance of pump-stations (especially within the Amu Darya), and that the Central Asian Scientific and Research Institute of Irrigation (SANIIRI) already proposed water charges for Operation and Maintenance for collective farms by mid-1970s (Dukhovny and de Schuetter 2011) one could question the rationale for the introduced pump-stations for water compensation within STTs. Different authors present different rationales for the expansion of irrigated areas to unsustainable levels, Thurman (2001) blames the over construction of the irrigation system on the irrigation bureaucracy itself, with the argument of wanting to expand its budgets, Weinthal (2002) mentions the priority to increase cotton production and hence, naturally maintaining production, Dukhovny and de Schuetter (2011) highlight rapidly increasing population and employment issues, and therefore the potential of having to resettle larger parts of the population, Pak and Wegerich (2014) highlight water rights of established water users and therefore the danger of potentially losing water rights of the province. It is likely, that a combination of these different factors led to the decision or continuing with the existing irrigation systems.

Dukhovny and de Schuetter (2011) highlight that operation and maintenance fell within the responsibility of the water authorities, and that during the 1980s about 70 SUR/ha were allocated to water organisations for inter-farm canals. Already the electricity costs for operating pump-stations clearly outstripped these costs. Given that these increased costs for the irrigation department could be clearly allocated to transboundary compensation mechanisms, one could question why these costs would not be separately listed and possibly submitted to the higher level. Since the Uzbek SRR had already developed its irrigation system, one could assume that there was an understanding why the upstream Kyrgyz SSR wanted to develop its system. It is also likely, because the Uzbek SSR was late with the construction of the Sokh reservoir and the LSKR canal was finally not approved that therefore there might have been a sentiment of not claiming compensation for the constructed pump-stations. In addition, it is possible that the relatively smaller scales of the pump-stations (compared to the reservoirs) and relatively incremental steps of their construction contributed to the fact that they remained out of attention in riparian negotiations.

The pump-stations became not only a costly strategy to cope with water shortages, but also not sustainable when compared to the benefits from irrigation in the long run. In the

short run, social benefits of supporting and mitigating the risks for the affected local population are clear. However, in the longer run one might assume that the gradual resettlement plan could have saved considerable costs and could have increased benefits. Even in the best case scenario of productivity (Keith and McKinney 1997; Bucknall et al. 2005; Khamraev 2011), the net irrigation benefits would be only marginal compared to the operational, maintenance and rehabilitation costs of pump-stations with lift height above 50 meters.

7. Conclusion

While the benefit sharing approach or the mutual gains approach talks about win-win solutions, this paper highlighted that considering the costs of cooperation are crucial. The past perceived benefits for the Uzbek SSR for compensating for upstream irrigation expansion in Kyrgyz SSR do not look that beneficial if the costs for the Uzbek SSR were considered. These costs were already too high for the Soviet standards and in a political and economic environment which was still integrated. Certainly, these costs are too high looking at it again after independence. Integrating costs into the benefit sharing approach are crucial.

Past perceived benefits for the construction of compensatory water supply pump stations either for the bureaucracy itself, fulfilling cotton quota, maintaining water rights or coping with population pressure are from the current perspective outdated. The bureaucracy has too high electricity costs (Khamraev 2011), cotton quota is reducing (and was already reduced in the end of the 1980s during the Soviet Union) (Spoor and Krutov 2003), water rights within the basin have stopped functioning after independence (O'Hara 2000, Weinthal 2002), and although the population pressure might still exist, the privatization of agricultural land has significantly reduced the labor force and therefore the population benefitting from agriculture (Djanibekov 2008; Mukhamedova and Wegerich 2014). Hence, what might be perceived as benefits at one point of time, might not be perceived as benefits in the future. This highlights that perceived benefits are not written in stone, and therefore benefit sharing agreement should be seen as temporarily and therefore revisable.

Within the Syr Darya basin the current focus on benefit sharing is on large upstream dams alone (such as the Toktogul and Kairakkum). The current focus suggests that downstream states only benefited from upstream developments and should today pay for the services provided, such as the operation of dams. The case study highlighted that this focus is one-sided, and other infrastructure as well as the costs of allowing the late developer Kyrgyzstan to expand its irrigated area should be considered as well. Including pump stations within the proposed benefit sharing approach could entail free generated electricity for compensatory pump-stations as well as balancing of maintenance costs of upstream and downstream water infrastructure.

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5 Dealing with 'Baggage' in Riparian Relationship. How Path Dependency Can Explain Dynamics in Riparian Water Allocation: Insights from the Detail-Rich Ferghana Valley

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Dealing with 'baggage' in riparian relationship. How path dependency can explain dynamics in riparian water allocation: insights from the detail-rich Ferghana Valley

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Abstract

The purpose of this paper is to analyze how socio-economic and techno-ecological characteristics can lead to three different degrees of changes in riparian water sharing in the long run. A longitudinal study of five rivers in the Ferghana Valley is presented to understand how riparians responded when they faced pressure to reallocate. The impact of path dependency on the dynamics in transboundary water allocations is studied in a systematic way. Therewith drivers of pressure that trigger a new formal agreement are differentiated from sources of path dependency that lead to pent-up pressure of not even willingness to agree to a formal regulation or the resistance in the de-facto implementation of the agreement. The analysis reveals three key sources of path dependency: (i) vested interests, (ii) infrastructure control and (iii) network effects which form the so called 'baggage' in relationship. The paper discusses the interplay among these sources and corresponding impact on the short- and long-term outcomes. Understanding of the existing 'baggage' in relations allows making predictions about a likely negotiation outcome and degree of change in future reallocations under a certain combination of socio-economic characteristics and institutional environment.

Key words: path dependency; longitudinal study; transboundary water agreements; formal and de-facto change; Ferghana Valley

1. Introduction

Although within the United Nations Watercourses Convention it is stated that riparian states are free to harmonize past agreements with the principles of the convention, there are calls to reevaluate past agreements due to overall economic and development changes as well as new international agendas (Wegerich and Olsson 2010; Brooks et al. 2013; Salman 2014; Wouters 2014). Similarly, growing concerns regarding environmental needs and climate change have triggered calls for a reevaluation of past water allocation agreements (Sanchez and Roberts 2014; World Economic Forum 2015). At the same time, scholars reflect on how treaties could be designed for coping best with new challenges (Fischhendler 2004; De Stefano et al. 2010; Drieschova et al. 2011). Although large scale studies have been conducted on what mechanisms are utilized within agreements to address changes (e.g. Drieschova et al. 2011; De Bruyne and Fischhendler 2013), there have been only few studies showing how basin development trajectories have triggered changes in agreements (Pak et al. 2014; Soliev et al. 2015). Adapting from the conflict and cooperation continuum approach on international basins (Yoffe et al. 2003; Zeitoun and Mirumachi 2008; Sadoff and Grey 2005), here nuances of changes in formal and de-facto riparian water allocation are analyzed within multiple transboundary sub-basins in the Ferghana Valley of Central Asia. Building on path dependency of institutions the analysis attempts to identify key sources of path dependency determining various degrees of changes in water allocations. This allows for the first time to come based on existing characteristics to prediction on future adaptations. This is particularly important with growing necessity to accommodate future climate change and scarcity needs. The purpose is to find out sources of path dependency and long-term dynamics in water negotiation determining the various outcomes.

Therefore, the focus is not on one agreement, but in fact on the history of agreements in three case studies selected using the ‘most similar’ comparative method (Lijphart 1971; George and Bennett 2005). There is hardly any broad and longitudinal approach as this to be found in the current literature. The Ferghana Valley, shared by Kyrgyzstan, Tajikistan and Uzbekistan, presents an opportunity to apply such an approach, as it has a long history of changing water agreements on a large number of small transboundary tributaries (Wegerich et al. 2012a, 2012b; Pak et al. 2014; Soliev et al. 2015) and transboundary infrastructure (Pak and Wegerich 2014). The early agreements on these transboundary basins go back to the 1940s. Although historically these small tributaries were in the same country, the Soviet Union, due to the differences in development of the individual Soviet Republics and the environmental conditions, each tributary has its own history of water sharing agreements. To understand the dynamics in these allocation decisions, protocols of meetings where water-sharing agreements were reached, historical correspondence, reports on implementation, wider government documents as well as existing literature reflecting the nature of relationship among the

riparians were studied using an in-depth qualitative content analysis verified with information from key informants in the province water management departments.

The paper continues with the theoretical framework explaining the concept and different degrees of path dependency in riparian water allocation. Then materials and methods are presented followed by results of analysis and their discussion of how sources of path dependency contributed to the three distinct degrees in the long-term outcome: no or little, incremental and fundamental change. Finally, discussion is extended to a broader significance of the study results for the scholarship on transboundary water management before drawing main conclusions in the final section.

2. Path Dependency in Riparian Water Allocation

Path dependency has been emerging as an important concept explaining the possibility of and the ways that a change can take place in allocation institutions (Heinmiller 2009; Theesfeld and MacKinnon 2014). North (1990, 1994, 1995, 2005) has argued that while continuously changing circumstances will put pressure on existing institutions and require adoption of new solutions, historically formed path dependency in these institutions will resist to or limit the scope of changes. More generally, in economic literature path dependency is explained by increasing returns from staying on the taken path (Arthur 1994) where sources such as (i) high set up (and sunk) costs, (ii) learning effects, (iii) coordination effects and (iv) adaptive expectations provide the existing institutions with so called 'positive feedback' (see Weber de Morais et al. 2015 for a summary). In addition, there are sources of non-increasing returns which in certain combinations with significant fixed (sunk) costs might be sufficient for path dependency (Arrow 2000). Among these, Kay (2005) highlighted (i) vested interests of existing actors, (ii) network effects from administrative capacities and (iii) existence of formal and informal contracts with individuals.

Until recently, the broader literature on the continuous need for water reallocation in river basins has largely lacked a longitudinal perspective. For example, Ohlsson and Turton (1999), similarly Molle et al. (2003), argued that growing pressure on water resources would lead to corresponding adaptation – pushing towards first, 'more water', then 'more use per drop' and finally, 'more value per drop' – resulting in similar patterns or trajectory of development in river basins. Forecasting continuously increasing water stress on the one hand and explaining how societies should adapt in order to cope with the scarcity on the other hand, possible resistance resulting from existing institutional arrangements in response to new reforms has remained unexplored. Likewise, in a more recent work, Molle et al. (2010: 575) explain "how to best share scarce water supplies" from state, user or market perspectives. They stress the

increasing importance of reallocations. However, the question of what a reallocation could mean for existing actors and allocation institutions is not covered. Molle and Berkhoff (2009: 6) show in the reallocation of water resources from agriculture to cities that "cities select options that go along the "path of least resistance," whereby economic, social and political costs are considered in conjunction".

In addition to water stress, the nature of established relationship between riparians is one of the most commonly identified factors when it comes to transboundary water allocation (e.g. Fischhendler 2004; Zeitoun and Warner 2006; Mirumachi and Alan 2007). Trust, power asymmetry, riparian position as well as issue linkages are among those shaping the relationship between riparians in a transboundary setting. Nevertheless, to this day, there is hardly any study specifically focusing on the impact of path dependency on the dynamics in transboundary water allocations in a systematic way. Findings of few available studies, although not focused specifically on changes in transboundary water allocation, generally support that reforms are increasingly difficult with the presence of established allocation institutions (Heinmiller 2009; Libecap 2011; Marshall 2013; McCann 2013; Theesfeld and MacKinnon 2014; Garrick et al. 2015). In this respect, a brief overview by Hensengerth et al. (2011: 27) challenges the often replicated contrasting assumption of Wolf (2004) that "… in river basins with a history of cooperation and institutions to build on, cooperation in new areas can be achieved more easily than in basins where no institutions exist, since existing mechanisms can be used to exchange information and build mutual confidence, which reduces transaction costs." Instead, Hensengerth et al. (2011) point to a number of cases where conflicts emerged despite established cooperation.

The question is then whether it is possible to distinguish among different degrees of path dependency to explain this varying effect of established institutions more holistically. Theesfeld and MacKinnon (2014) suggest that there is a continuum from no or little change to fundamental or rapid change. Studying transformations in water allocation in the US West, they argue that path dependence can result in incremental changes where small changes occur without threatening the survival of the entire system. Within incremental changes Theesfeld and MacKinnon (2014: 110) stressed the importance of distinguishing between 'successful', which accommodate new needs, and inadequate ('too little too late') changes, which ultimately allow accumulated "pressure of unmet needs to push the system over threshold and collapse". It is in line with what North (1990) described as adaptive efficiency: incremental change might or might not be efficient in terms of responding to new challenges (also see Marshall 2005). Hence, as shown in Figure 1, it is possible to distinguish no or little, incremental and fundamental change as a result of collision between drivers pressing towards a change and sources of path dependency resisting to a change.

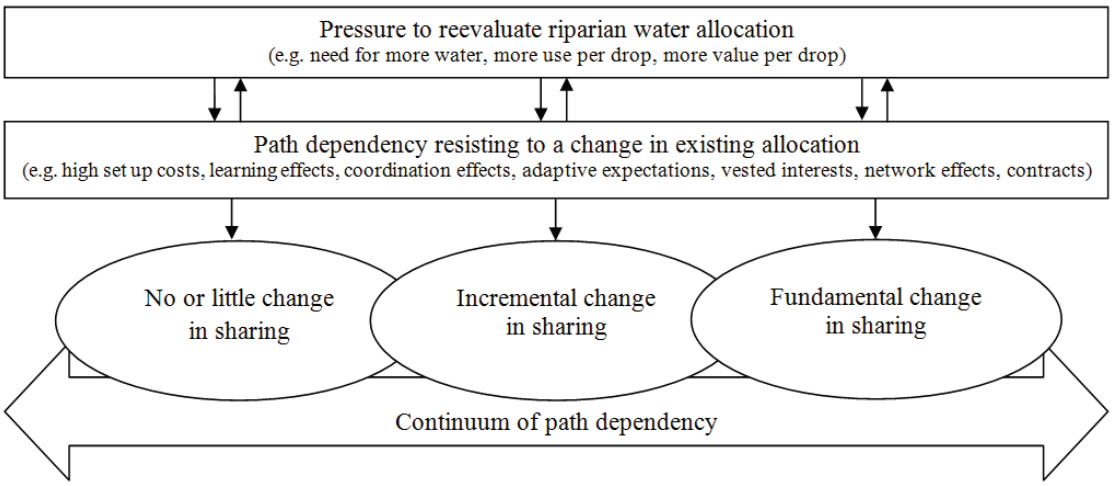


Fig. 1. Continuum of path dependency in riparian water reallocation.

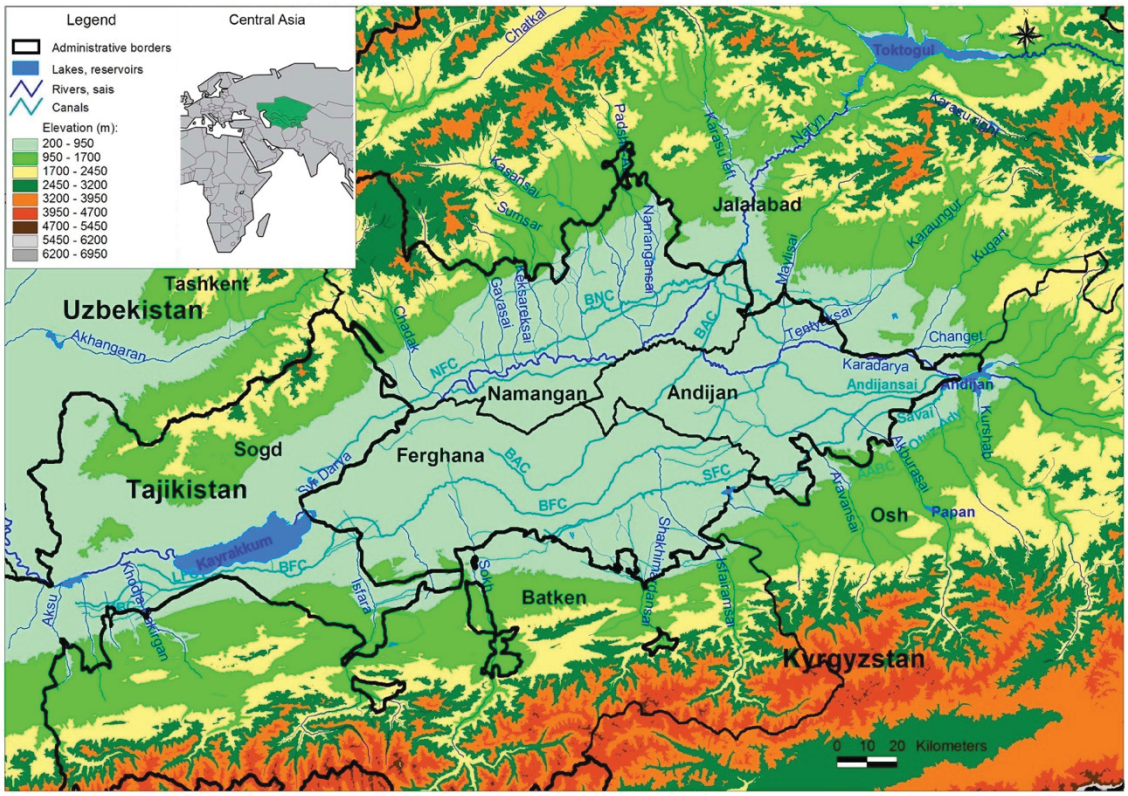
Obviously, there is normally a discrepancy between formal and informal/de-facto water sharing arrangements. In a complex resource and institutional environment, it is reasonable to expect some discrepancy between an agreement and its implementation. Among others, Luhmann (1995), also specifically from institutional perspective North (2003), have stressed that social systems operate with imperfect information at all times due to limited cognitive abilities, differences in perceptions and complexity of the environment. Pak et al. (2014) show how lack of data to determine annual or decadal flows, inaccurate data due to negligence of maintenance or lack of control on water abstraction can result in deviations of implementation from formal sharing agreements on varying intensities (see also SIC ICWC 2011). The paper intends to extend this framework by analyzing the long-term changes in water allocation. To categorize the presented cases, although the history of the formal agreements is studied in depth, the particular attention is given to the de-facto outcomes of the implementation of these plans.

3. Materials and Methods

3.1. Study area

The Ferghana Valley is situated in the upstream Syr Darya Basin (Figure 2). While the central part of the valley covers the territories of Andijan, Ferghana, Namangan provinces of Uzbekistan, the surrounding mountainous slopes are mostly part of Batken, Jalalabad, Osh provinces of Kyrgyzstan and Sogd province of Tajikistan. The Naryn, with an average annual discharge of 13.8 km^3, and the Karadarya (3.9 km^3) originate in the mountains of Kyrgyzstan and converge in Uzbekistan forming the main stem of the Syr Darya (37 km^3). The two main tributaries are regulated by the Toktogul (14 km^3 of storage capacity) and Andijan (1.75 km^3) reservoirs, at the exit from the valley the Syr Darya is regulated by the Kayrakkum (2.6 km^3) reservoir. There are also more than 20 smaller transboundary tributaries (STTs) with combined average annual flow of 7.8

km^3. These STTs feed the Naryn, Karadarya, Syr Darya as well as the canals constructed across the valley (Soliev et al. 2015).



AABC - Aravan-Akbura Canal, BAC - Big Andijan Canal, BFC - Big Ferghana Canal, BNC - Big Namangan Canal, KBC - Khodja-Bakirgan Canal, NFC - North Ferghana Canal, SFC - South Ferghana

Fig. 2. Transboundary water resources and infrastructure in the Ferghana Valley. Source: adapted from Soliev et al. (2015).

Historically, water allocation rules in the valley developed through complex multi-level decision processes (Soliev et al. 2015; Pak and Wegerich 2014; Pak et al. 2014). The pre-independence ideology, when the three riparian states were part of the Union of the Soviet Socialist Republics (USSR) as Kyrgyz SSR, Tajik SSR and Uzbek SSR respectively, was to develop lands to their maximum level and create a system of interconnected water infrastructure: first, to regulate the available flow; second, to be able to transfer water among different sources and reach different parts of the valley. Despite being part of one country, already starting in the 1950s the Republics gained increased autonomy directly negotiating projects among one another. In the 1970s the central government in Moscow actively encouraged competition and direct dispute resolution between the Republics; in the 1980s it became acceptable if the Republics officially challenged the decision of the central government (Soliev et al. 2015). Therefore, although often seen as a single complex system, a more detailed look at individual rivers shows their different pathways of allocation adjustments at different points in time.

3.2.Data

The data represent interactions among the riparians on national, provincial and district levels signed or prepared to manage the shared land and water resources and other related matters reflected in 24 documents covering the period between 1946 and 2012 (detailed in Appendix). In addition, data with main characteristics of transboundary infrastructure (Soliev et al. 2015) and information on wider relevant developments were derived from the earlier studies (World Bank 2004; UNEP 2004; SIC ICWC 2011).

3.3.Methods

A most similar comparative approach has been used to select the cases (Lijphart 1971; George and Bennett 2005). All rivers in the Ferghana Valley largely share a broader history and have similar techno-ecological basin development trajectories (expansion of irrigation systems; change of technology - canals for water transfers, reservoirs; pump stations for lift). This allows focusing on sources of path dependency which resulted in differences these basins have experienced in reaching new allocation agreements and during their implementation. In selecting the five specific STTs the attention was paid to their potential positions on the path dependency continuum.

The first case study, the Maylisai river, shows no or little changes of de-facto arrangements despite fundamental changes in formal allocation agreements. The second case study bundles the Sokh, Isfayramsai and Shakhimardansai rivers, which experienced incremental changes in both formal and de-facto arrangements. The third case study, the Isfara river, shows a fundamental change in de-facto riparian allocation which followed formal incremental changes.

The case studies are based on an in-depth qualitative analysis of the documents described in Section 3.2. First, the documents are analyzed to establish the chronology of formal changes in allocations and drivers of pressure leading to these decisions. Second, informal/de-facto changes are identified through analysis of documents related to implementation of water sharing agreements. Third, each case study (see Appendix) is examined against the set of explanatory variables reviewed in Section 2: the reasons for the systematic appearance of discrepancies between formal and de-facto changes in allocations are analyzed. As a result of the three step analysis, key sources of path dependency applicable to riparian water allocation are suggested.

4. Results and Discussion

The summary of the three case studies (consisting of 5 different river basins) highlighting how formal and de-facto changes in riparian water allocation were triggered and implemented is presented in Table 1.

Table 1. Summary of case studies (see detailed description of changes in allocations in Appendix)

Case study	River	Agreement	Formal riparian share			Drivers of pressure leading to a new agreement	Sources of path dependency (resistance) and de-facto implementation	Short-term outcome (immediate, related to an individual agreement)	Long-term outcome (accumulated, related to all agreements)
			Kyrgyz	Uzbek	Tajik				
1	2	3	4	5	6	7	8	9	10
1	Maylisai	Protocol 23/08/1946	35%	65%	n/a	• Plan to adopt a basin approach and clarify sharing	• n/a	Institutionalization of the proportional water allocation	1) Area of irrigated lands and therefore water shares have been long disputed 2) Differences in understanding/interpretation of the rules persisted 3) Difficulties related to border-crossing after independence led to loss of control in allocation 4) Increase of unilateral withdrawals after independence (change in control) made downstream accept at least 18%
		Protocol 13/04/1966	75%	25%	n/a	• Plan to expand shared infrastructure and irrigated area (more water)	• Vested interests: A clause calling for a joint clarification of the irrigated area within the basin • Network effects: Misunderstanding of the new sharing arrangement between the sides and across the actors	Delay in implementation	
		Protocol 10/04/1980	82%	18%	n/a	• Plan to optimize water allocation across the valley (more water)	• Vested interests: Renewed commitment for joint clarification of the irrigated area • Network effects: Continued misunderstanding of the sharing arrangement between the sides and across the actors • Network effects: Issue linkages to other rivers and canals	Further delay in implementation	
2	Sokh	Protocol 7/06/1973	From 1 to 18% by 1977	99 to 82% by 1977	n/a	• Plan to compensate for concession elsewhere (lands for Toktogul) • Plan to expand infrastructure and irrigated area (more water)	• Vested interests: Need to agree on the design of the infrastructure (LSKR Canal, Sokh reservoir) • Network effects: Disapproval from Moscow of what was agreed by riparians • Network effects: Dependence on implementation of other projects due to issue linkages	Large agreement linked the issues but some elements of the large agreement were not approved Delay in implementation	1) Changes in shares were not contested 2) Separation of issues (from the Karadarya and due to disintegration of Batken as a province) is observed in all three rivers 3) Infrastructure control – development of irrigation infrastructure in Burgandy massif in expectation of increased water supply through LSKR Canal and Sokh reservoir – facilitated de-facto reallocation 4) Difficulties related to border-crossing and increase of unilateral withdrawals after independence, made downstream accept at least 50% allocation
		Protocol 10/04/1980	10%	90%	n/a	• Infrastructure control: Increased unilateral withdrawals upstream (Burgandy massif) • Plan to optimize water allocation across the valley (more water)	• Infrastructure control: Higher expectations due to irrigation networks constructed in advance • Network effects: Issue linkages to other rivers and canals	Upstream kept demanding (and withdrawing) more	
		Protocol 22/08/1989	23%	77%	n/a	• Infrastructure control (Burgandy), continued demands of upstream to compensate for lost opportunity (not implemented LSKR Canal and not completed Sokh reservoir)	• Vested interests: Financial crisis after independence with each riparian focusing on own interests • Network effects: Delink of issues as a result of creation of Batken province as a responsible riparian province	Vulnerable implementation due to delayed projects, which during the drought year 2001 led to oral agreement to share the river on 50/50 basis (did not work)	
	Isfayramsai	Protocol 10/04/1980	30%	70%	n/a	• Delinking issues: separation from Karadarya (more water) • Plan to optimize water allocation across the valley (more water)	• Network effects: level of issue linkages increased due to the 1980 Protocol which connected all water resources across the valley but decreased due to separation from the Karadarya and disintegration of Batken province	The same oral agreement in 2001 to share the river on 50/50 basis (worked)	
	Shakhimardan-sai	Protocol 10/04/1980	27%	73%	n/a	• Delinking issues: separation from Karadarya (more water) • Plan to optimize water allocation across the valley (more water)	• Network effects: level of issue linkages increased due to the 1980 Protocol which connected all water resources across the valley but decreased due to separation from the Karadarya and disintegration of Batken province	The same oral agreement in 2001 to share the river on 50/50 basis (worked)	
3	Isfara	Protocol 8-10/04/1946	2%	48%	50%	• Need to clarify sharing during vegetation period	• n/a	Institutionalization of the existing sharing	1) Changes in shares were long contested 2) Kyrgyz SSR persisted that downstream had better options and therefore was entitled to increases 3) Control over the river through Tortgul reservoir facilitated unilateral changes 4) Difficulties related to border-crossing after independence and high uncertainty led to exclusion of Uzbekistan from Isfara and of Tajikistan from BFC
		Protocol 1-3/04/1958	2%	41%	57%	• Reconstructed infrastructure (BFC)	• Network effects: Uncertainty as to the effect of linking the Isfara and BFC	Overall change was not significant	
		Protocol 10/04/1980	37%	8%	55%	• Plan to optimize water allocation across the valley	• Network effects: Tajik SSR did not participate in the meeting, Uzbek SSR did not approve	Riparians proposed and organized another meeting	
		Protocol 12/05/1980	17%	35%	48%	• Lack of agreement	• Network effects: Uncertainty as to the effect of the new infrastructure across the valley	Significant increase in shares, withdrawals for Kyrgyz SSR	
		Principle 1982	22%	38%	40%	• Infrastructure control (Tortgul), expansion plans upstream	• Vested interests: Increased inter-state competition each riparian focusing on own interests	Increased shares and withdrawals for Kyrgyz SSR	
		Protocol 16/05/1951	33%	33%	34%	• Infrastructure control (Tortgul), expansion plans upstream	• Vested interests: Financial crisis after independence with each riparian focusing on own interests	Increased shares and withdrawals for Kyrgyz SSR	

To refer to a specific detail from Table 1, the following acronyms are used in parenthesis (T1:CS2-C5), where, in this example, T1 stands for Table 1, CS2 for Case study 2 and C5 for Column 5. For the precision of analysis, it is important to distinguish short- and long-term outcomes (T1: C9 and C10): the first is seen in comparison of the changes within a case study and the other is among the case studies in a broader longitudinal perspective.

On the one hand, each case has had its own little-to-fundamental changes. The gradual filling of the Tortgul reservoir and corresponding increases in the Kyrgyz share on the Isfara river (T1:CS3-C9; Appendix: CS3) might be seen as incremental changes in the short-term, but the mutual exclusion of riparians altogether (Uzbekistan from the Isfara and Tajikistan from the BFC) can be seen as a fundamental change in the long run. In contrast, while the change to 50/50 sharing in the Sokh, Isfayramsai and Shakhimardansai through an oral agreement in 2001 (T1: CS2-C9; Appendix: CS2) might be seen as a fundamental change in the short-term, in the long run it can be viewed as part of incremental changes as the de-facto sharing did not change as fundamentally (Appendix: Figure A2). As expected, in relation to the time horizon taken in the analysis, it can be seen that a series of incremental changes over a long period of time can cumulate in very significant changes in institutions (Theesfeld and MacKinnon 2014). Thus, the degree of change at one place might look different if to consider the effectiveness of implementation and a longer time perspective.

On the other hand, comparing the cumulative outcomes from the three case studies allows deliberating on sources of path dependency leading to the different long-term scenarios along the continuum of no or little, incremental and fundamental change.

The institutional analysis shows that the longer the history of relations on a river or bundle of rivers was, the larger the ‘baggage’ (sources of path dependency) became. The scope and nature of each subsequent change was clearly affected by the accumulated issues. This highlights the importance of longitudinal studies to better understand the changes. The findings support the argument that a long-term relationship between riparians, even if cooperative, does not necessarily mean that reallocation in such basins will be easier; a change in such settings, in fact, might prove more complicated. For example, for downstream Uzbekistan improving the infrastructure such as in case of the reconstruction of the BFC in the Isfara case (Appendix: CS3) or increased flow regulation through a number of reservoirs in the Isfayramsai and Shakhimardansai case (Appendix: CS2) resulted in fact in continuous pressure from upstream Kyrgyzstan beyond previously agreed allocations. Such continuous pressure obviously creates strong disincentives to improve internal use or report any gains as it would entail new demands to reconsider allocations.

Interesting is the fact that the formal change in water allocations always had to be seen in combination with the expansion of cultivated land and thus the share of possible irrigated land. Obviously, countries use the ecological characteristics of irrigable land and the technological characteristics of already established infrastructure in their bargain over water allocation.

4.1.Drivers of pressure leading to a new allocation

The pressure towards concluding a new agreement largely came from the sides' needs to gain 'more water'. This was done primarily by integrating new infrastructure such as canal and pump-stations (Appendix: CS1) as well as reservoirs (Appendix: CS2 and CS3). To achieve more water, riparians also attempted to optimize allocations across different sources as in the case of the 1980 Protocol (T1:C3). This is in line with what earlier studies have suggested and generally could be seen as states pursuing their development plans (Ohlsson and Turton 1999; Molle 2003; Molle et al. 2010).

Two further drivers of pressure to reallocate water have been observed: financial shocks and climatic changes. The collapse of the Soviet Union created significant financial difficulties for all riparians. As Moscow stopped financing the republics, now they were on their own with massive already aging infrastructure, requiring more investments to operation and maintenance. The states had to restore economic and social stability and water became even more crucial for the national economies than before. Upstream Kyrgyzstan started using the Toktogul to produce more hydropower (Appendix: CS3), downstream could not fully fulfill its commitments to complete construction of the Sokh reservoir (Appendix: CS2) and started to look for solutions to meet its demands internally. At the same time, the riparians had to adjust their shares as a result of weather extreme as in the example of the Sokh, Isfayramsai and Shakhimardansai in 2001 (T1: CS2-C9; Appendix:CS2).

An interesting finding is that a need for 'more water' intensified the pressure when an agreement was not implemented timely. It can be seen how delays in measurement and amendment of irrigated areas in the Maylisai (Appendix: CS1), delays in approval and implementation of the LSKR Canal and Sokh reservoir resulted in sharp unilateral changes by Kyrgyzstan later on (Appendix: CS2). However, looking at the drivers of pressure alone still does not fully reveal the different patterns in the long-term changes.

A strategy could indeed be first to follow the pressure and agree on a formal reform of the allocation but in its implementation to act rather path dependent and only allow for incremental steps in changing the de-facto water allocation.

4.2.Sources of path dependency and resistance to change

The key sources of path dependency observed within the case studies (Table 1 and Appendix) are hereby grouped and explained as following:

(i) Vested interests: institutionalization of water as a source of (economic) benefits creates opportunistic incentives; a riparian with established entitlement resists to reallocation affecting its share or benefits negatively.

In the analyzed cases, vested interests were found to be institutionalized within the proportional allocation principle: this overarching principle connected the area of land included in the plan to the water entitlements. In contrast to the existing literature (Heinmiller 2009; Kay 2005) vested interests here are not directly of established individual users, rather more systemic. The more land a riparian could include in the scheme, the more water could be claimed to irrigate these lands. The most notable example is the clause in the 1966 Maylisai agreement (T1:CS1-C3; Appendix: CS1) calling for a clarification of the irrigated area within the basin, which led to long-standing disagreements. A clarification was clearly hindered by vested interests, since it could have implied a reduction of the water share. Generally, vested interests were present at all times (in the other two cases, the riparians had vested interests in greater shares at all times, too) and hence can be seen as the main source of path dependency; however, this very universal presence of vested interests does not help understand the differences in paths.

(ii) Infrastructure control: infrastructure built for implementing allocation decisions create a long-lasting control over water; control over infrastructure enables its holder(s) to implement unilateral decisions.

The cases demonstrated that the control over infrastructure was crucial for the negotiations of an allocation path. It shows that large infrastructure costs cannot be fully seen as sunk costs (as e.g. in Heinmiller 2009). The control that comes with the water infrastructure, especially in a transboundary setting, indeed has a significant value for decision making over time. In the Maylisai (Appendix: CS1), when Andijan province had control, it could implement its plans even when contested by its riparian. With the loss of control over the infrastructure due to difficulties in border-crossing, Jalalabad province, the upstream riparian, gained increased control and started implementing its own plan. The unilateral withdrawals by Kyrgyzstan in the Sokh (irrigation networks in the Burgandy massif) (Appendix: CS2) and Isfara (Tortgul reservoir) (Appendix: CS3) also exemplify how control over infrastructure triggered de-facto changes. Overall, infrastructure appears to provide the means to materialize vested interests.

(iii) Network effects: physical and institutional complexity of the system within and across jurisdictions make it difficult to undertake partial reforms without undertaking reforms to the entire socio-techno-ecological network; (a) multiple governance levels of administrative responsibilities, (b) physical interdependence of infrastructure, (c) issue linkages within agreements make up the network effects. Further, (d) lack of information and knowledge intensify them.

The analysis showed how the continuously increasing physical (infrastructure) and institutional (protocols and decisions with references to one another) complexity created room for justification of unilateral plans. Further, decisions were often made on one level while actors on lower levels, responsible for implementation, did not see the big picture and lost the connections over time. This is in line with Heinmiller's (2009) explanation of network effects and broadens it by singling out the sub-categories of path dependency sources. In the Maylisai case, while there was a clear agreement at the beginning, interpretation of the sharing principle was increasingly contested by the actors involved later (whether intentionally or due to loss of knowledge) (Appendix: CS1). The increased use of the Maylisai river by Andijan province in the 1980s as claimed by Kyrgyz side was implicitly justified as a response to reduced inflows on other rivers (Akburasai, Aravansai) (Appendix: CS1). The history of the Burgandy massif demonstrates how details of the earlier agreements on expansion in the Burgandy linked to the Toktogul and Andijan reservoirs in the 1960s were partially lost by the 1980s (Appendix: CS2). The increased unilateral withdrawals in the Sokh (Appendix: CS2) and Isfara (Appendix: CS3) by Batken province were explicitly justified with the non-completion of the LSKR Canal. In 1989, the significant increase in the Kyrgyz share from the Sokh (greater than what was previously agreed) did not prevent them from continuing their claims on the LSKR Canal and Sokh reservoir (Appendix: CS2). Indeed, the room for manipulation becomes greater in absence or obsolescence of metering and monitoring infrastructure able to provide all riparians with neutral and instant flow of data as well as possible loss of nuances due to changes in staff.

4.3.Interplay among drivers of pressure and sources of path dependency determining the degree of change

Overall, while control over infrastructure provides the means to materialize the vested interests, network effects provide the room to justify unilateral decisions should a riparian deviate from an agreement. Based on the conducted research, how interplay among the sources of path dependency can affect the forthcoming degree of change in reallocation is illustrated in Figure 3.

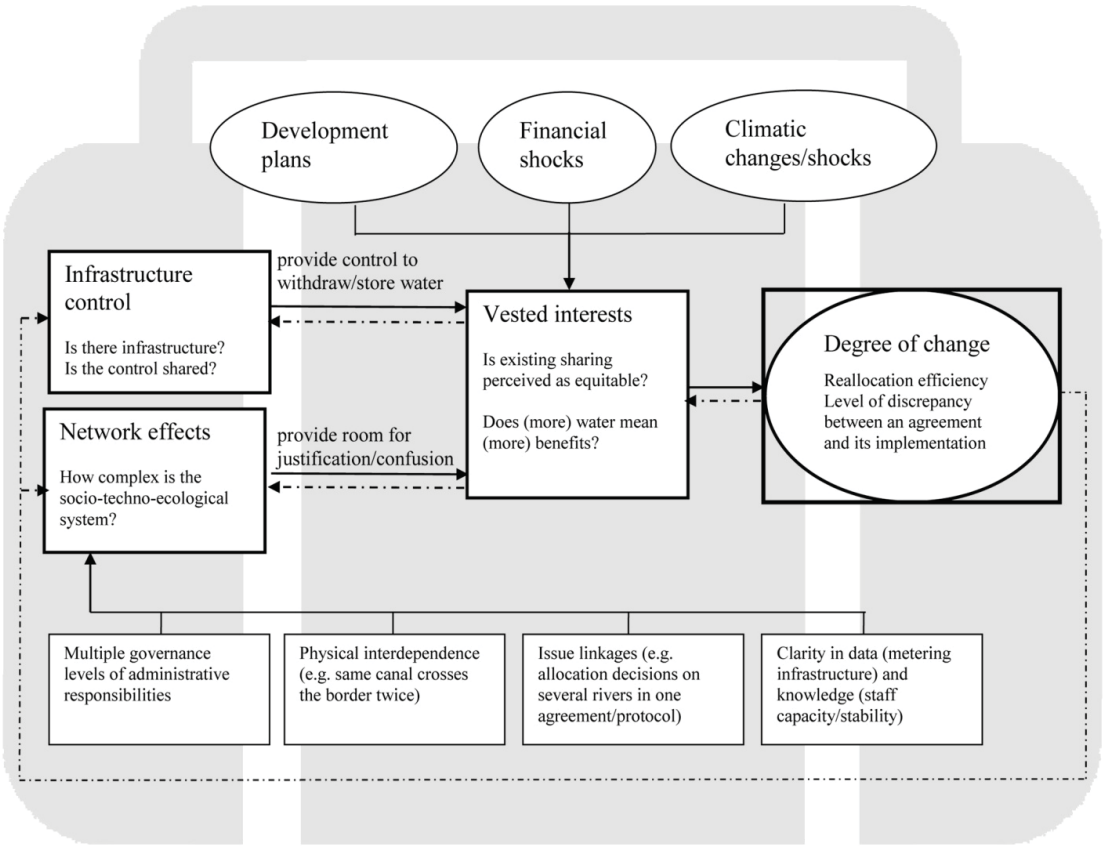


Fig. 3. 'Baggage' in riparian relationship: interplay among drivers of pressure and sources of path dependency determining the degree of change in riparian water reallocation. Note: drivers of pressure are displayed in oval figures, sources of path dependency in rectangular, arrows denote impact and its direction, dashed arrows show feedback.

Institutional change, exemplified here as new formal allocation agreements, can encompass both (i) flexibility which enables adaptation to upcoming challenges and (ii) path dependency which limits flexibility. A balance between these two can determine whether and how fast an institution can adapt to possible changes or fails to do so and collapses (Theesfeld and MacKinnon 2014). The discrepancy between formal and de-facto agreements is partly due to the fact that the formal changes might call for more than the actors are willing to give based on their circumstances resulting in path dependency and only allowing an incremental change. Three outcomes have been distinguished: no or little, incremental and fundamental change as result of a reform. The analysis shows that a fundamental change might occur because of both no or little change due to unresolved pent-up pressure (Maylisai case) and a number of incremental changes (Isfara case, partly Sokh, Isfayramsai, Shakhimardansai case). However, the obvious difference is whether such a fundamental change is a shock to the system or a planned and better controllable transition. Thus, an incremental de-facto change in water allocation which is in line with incremental formal changes might be more sustainable in the long-run.

In particular, the effect of issue linkages should be highlighted. Although issue linkages, such as those established with land and energy sectors or across different river basins, helped at the negotiation phase and served as an enforcement mechanism during implementation (reverse riparian positions); separation of previously linked issues facilitated reallocations. Though, the implication was (partially) revoked previous commitments. In the Maylisai, the long-standing contested interpretations were a result of the strong network effects due to the complexity of new infrastructure and issue linkages with other sources. Separation from the Karadarya helped to change allocations in the Isfayramsai and Shakhimardansai. Further, the upgrade of Batken district to a province level effectively delinked commitments of Osh province in the cases of Sokh, Isfayramsai and Shakhimardansai as well as in the case of the Isfara. The latter demonstrates how riparians would prefer parting their ways, be it possible technically.

Finally, although the outcomes with fundamental change within each case study manifested themselves differently (exclusion of riparians in the Isfara; 50/50 sharing in the Sokh, Isfayramsai, Shakhimardansai; acceptance of 82/18 by Uzbekistan in the Maylisai), their timing points to how financial and climatic shocks intensified the vested interests. The independence and consequences thereof (loss of technical control over water, land reforms, budget cuts, administrative reforms, competing sectors for state support) and increased variability due to climatic changes, e.g. the drought in 2001, appear to have been the final trigger for the outburst of pent-up pressure (Figure 3).

4.4.Broader implications: vested interests, infrastructure control and network effects

Assuming vested interests present as they were in our cases, infrastructure upstream and being in unilateral control of the infrastructure appears to be a general risk for stability in relationship of riparians with ‘baggage’ where an upstream riparian has development needs/ambitions related to shared water resources (vested interests) (Wegerich and Olsson 2010). This phenomenon can be proven also in other parts of the world, such as in the recent advances in the construction of the Grand Ethiopian Renaissance Dam in the Nile which made Egypt negotiate with Ethiopia (Tawfik 2015). The accumulated pressure from long-standing disagreements with no or little change resulted in a fundamental change. Looking further broadly, the lack of ultimate overarching authority in a transboundary setting – arguably the most challenging feature of transboundary water management – makes dialogue and whether one can convince other riparian(s) as well as international community increasingly important for how much resistance intended reforms will face. “Soft power of persuasion” described by Zeitoun et al. (2011: 159) comes into play. Then, the question of whether upstream honors an agreement or not increasingly becomes a matter of justification, amplifying the uncertainty for downstream with each infrastructure project upstream. Therefore, it

might be understandable that countries downstream are often opposed to upstream large-scale infrastructure and generally prefer smaller incremental changes.

At the same time, for incremental changes to be effective or to achieve adaptive efficiency (North 1990), it is important that a reform has minimal network effects preventing unpredictable discrepancy between an agreement and its implementation. The findings on the network effects are also interesting in the light of recent literature increasingly viewing issue linkages and benefit sharing as tools for enhancing cooperation (e.g. Sadoff and Grey 2002; Sadoff and Grey 2005; Phillips et al. 2006; Pham Do et al. 2012). While considering more options indeed increases the chances of reaching a new agreement, increased complexity affects implementation of agreements both by reducing controllability of individual issues (see also Zeitoun et al. (2016) for importance of analysis fitting the state of knowledge processed) and by creating linkages where a side with a more favorable position could take advantage on other linked issues (Soliev et al. 2015). Similarly, the findings on network effects expand the hydro-hegemony framework (Zeitoun and Warner 2006): sequencing of arguments might suffice in combination with a favorable riparian position and exploitation potential for exercising hegemony which makes power as such (e.g. military, economic) much less relevant.

Finally, it is fascinating how sufficiently strong network effects, where riparians are in need of development but do not have technical capacities to fully monitor water flow, can create conditions inherently unfavorable to trust. Even when a riparian receives less water due to natural variability, the accumulated ‘baggage’ in relationship can easily push this riparian towards defensive strategies. This riparian will have to compensate its ‘loss’ from other sources or in other ways altogether (through arrangements in other sectors) due to pressing development needs since efficient negotiation is highly unlikely. That, in turn, will most likely have reciprocal consequences leading to an endless domino effect. Hence, it appears that establishing the full technical control of runoff – transparent measuring infrastructure allowing instant flow of data for all sides and continuity of highly professional staff – should be of highest priority and starting point in cases with rich history of relationship and aging infrastructure. Improving clarity of data should be followed by achieving absolutely clear decisions on validity of historical agreements. Only when the data and rules are not constantly questioned, reallocation in an environment of high institutional and geographic complexity becomes implementable in an effective way.

5. Conclusions

The study examined how negotiation and implementation of reallocation decisions among transboundary riparians in the Ferghana Valley resulted in three different outcomes along the continuum of path dependency: no or little, incremental and fundamental change. It showed how development needs, financial and climatic shocks pushed towards reallocation. However, the institutional analysis revealed that the degree of change in reallocation was largely determined by interplay of three sources of path dependency: (i) vested interests, (ii) infrastructure control and (iii) network effects. The universal positive feedback proved to be from vested interests as an incentive of 'getting more water' was institutionalized within the proportional sharing principle. The strongest manifestation of vested interests took place when large infrastructure granted control, and network effects (complexity) provided reason for implementation of unilateral plans. Network effects came out to be as the most decisive source of path dependency, strong network effects led to persistence of delay in implementation of reallocation over long time. The partial and gradual separation of issues and therefore reduced network effects resulted in corresponding incremental reallocations. It was when existing issues in bundle were delinked both physically and institutionally, the fundamental change leading to exclusion of riparians took place.

Overall, the study brought forward the importance of dealing with 'baggage' to be able to effectively respond to new challenges. The success of reforms, negotiation and implementation of new allocation decisions will greatly depend on how well these processes take into account the unresolved issues and pent-up pressure. Just as the International Network of Basin Organizations (INBO) has recently called for quick actions in connection with the 2015 Paris Pact (INBO 2016), the growing pressure to get 'more water', 'more drop per use' and 'more value per drop' will move transboundary riparians towards reforms (infrastructure projects, optimization models). In this context, knowledge about the riparian position along the continuum of path dependency as well as on the interplay of key sources of path dependency will be necessary to make the formal reallocations effective. The findings of the study highlighted the central role of clarity in knowledge and hence improving technical and personnel capacities, and the need for caution in respect of reforms intensifying network effects which in the long run increase complexity and make the system highly prone to financial and climatic shocks. This is especially important in the light of increasingly promoted approaches calling for higher levels of linkages within and across jurisdictions and issues such as benefit sharing in transboundary basins.

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Appendix to the Manuscript "Dealing with 'baggage' in riparian relationship. How path dependency can explain dynamics in riparian water allocation: insights from the detail-rich Ferghana Valley"

Dynamics in riparian water allocation in three case studies from the Ferghana Valley

Case study 1. Maylisai river: no or little change

The Maylisai river is a typical case study demonstrating how water resource development can result in a number of changes in formal agreements while their de-facto implementation might be delayed.

The Maylisai river is located between the Naryn and Karadarya (in the east of the Ferghana Valley). It has an average annual runoff of 273 million m^3 (8.68 m^3/s) and catchment area of 692 km^2 (Chub 2007). The Maylisai originates in Jalalabad province (part of Osh province till 1990) of Kyrgyzstan and enters the territory of Andijan province of Uzbekistan in Madaniyat village.

The first allocation agreement was reached in 1946 (Protocol 1946). It is assumed that the agreement institutionalized the allocation existing at the time (35% for the Kyrgyz SSR and 65% for the Uzbek SSR). With land reforms, i.e. re-distribution and development, being the highest priority of the time, riparian republics were expected to withdraw water proportionally to their irrigated area size (Soliev et al. 2015).

A new agreement came in 1966 (Protocol 1966), which reallocated the shares to 75% (3.9 m^3/s) for the Kyrgyz SSR and 25% (1.3 m^3/s) for the Uzbek SSR. The reallocation was connected to new infrastructure (the Left-Shore Naryn Canal and Druzhba pump-station) allowing the expansion of the irrigated area for both riparian republics through water transfer from the Naryn (main tributary). With the new allocation, despite the mentioned significant change in percentages in the Maylisai river itself, amount of water per hectare remained close to equal if the lands under the new infrastructure are taken into account (Table A1). The total allocation was agreed as 12.82 m^3/s for 10,998 ha in the Kyrgyz SSR and 10.13 m^3/s for 8793 ha in the Uzbek SSR.

Table A1. Land and water allocation between Kyrgyz and Uzbek SSRs in the Maylisai system adopted with the design of the Left-Shore Naryn Canal with water intake from the Naryn

Water intake	**Kyrgyz SSR**		**Uzbek SSR**	
	Area, ha	**Runoff, m^3/s**	**Area, ha**	**Runoff, m^3/s**
Left-Shore Naryn Canal (including expansion and land transfers)	7368	8.92	7653	8.83
Maylisai river (upper zone of the system above the machine canal)	3630	3.9 (75%)	1140	1.3 (25%)
Total for the system after the construction of the Left-Shore Naryn Canal	10,998	12.82 (56%)	8793	10.13 (44%)

Source: Protocol (1966)

The table shows that the reallocation was an adequate change in response to added capacities. What might seem as a fundamental change at first did not impact the de-facto proportional arrangements significantly. In addition, the numbers were estimates only as they were based on future expansion plans in several areas (Protocol 1966). Consequently, already in 1968, the Kyrgyz and Uzbek SSRs agreed to clarify the actual lands of the Uzbek SSR under the Maylisai STT and if necessary amend the allocation of water shares agreed within 1966 Protocol (Protocol 1968). The agreement was on the ministerial level and implementation – actual measurement and amendment of the previous allocation agreement – was delegated to the Andijan and Osh province Water Management Departments (WMD).

A series of disagreements over implementation were recorded since then. In 1974 the Kyrgyz SSR claimed that their de-facto share was still 35% instead of 75% (Reference Certificate 1974). The measurement of the irrigated lands was still pending since the sides disagreed as to which lands should have been included in the system. In addition, it seems that there was confusion with interpretation of data across the network of actors. It was not clear whether 75% as claimed by the Osh province WMD referred to the Maylisai river only or to the entire system since the explanation was not connected directly with the Maylisai river but with the fact that the Druzhba pump-station was providing less than agreed. It appears that the terms ‘Maylisai river’ and ‘Maylisai system’ should have meant two different allocations: the first one – ‘75/25’, and the second one – ‘equal proportions’; the latter itself at times was misinterpreted as ‘50/50’. The data show that not all participants of the process fully understood the difference and often used only the term ‘Maylisai’ indiscriminately. The Andijan province WMD, who was in custody of the infrastructure and responsible for implementation of allocation, persisted that the new agreement meant equal sharing from the system.

In 1980, the new Protocol (1980), which connected all small rivers and their infrastructure across the valley with the main stem of the Syr Darya, allocated the shares

from the Maylisai as 82% for the Kyrgyz SSR and 18% for the Uzbek SSR. Protocol (1980) did not clarify whether the new sharing referred to the river only or to the entire system either. To implement the new Protocol, the Osh and Andijan province WMDs concluded a new Agreement (1980), whereby they renewed their commitments from 1968 to coordinate clarification of the actual lands under the Maylisai system. Issues linkages with other canals and rivers (Right-Shore Kampyr-Ravat and Savai Canals controlled by Andijan province, Akburasai and Aravansai rivers controlled by Osh province) were established in the agreement where each side had responsibilities to deliver water to the other side. Already in the following year, the Osh province WMD filed a complaint with a similar nature of confusion that "under the Maylisai system" although their share was 82%, actual withdrawn was 50% (Reference Certificate 1981). Finally, in 1985, in response to the request of the Osh province WMD to recalculate the shares, the Andijan province WMD explained that because joint clarification of lands was still not undertaken the shares should have remained as 50/50 on the Maylisai river and as 45/55 on the Druzhba pump-station for the Kyrgyz and Uzbek SSRs respectively (Letter 1985). Furthermore, the response letter from the Andijan province WMD reminded of other sources (Akburasai and Aravansai rivers) where its share had not been received in full.

The disagreement as to what should be the exact shares from the Maylisai river and the broader system directly translated to the period after independence (after 1991). The financial crisis hit the water management departments and with difficulties in border crossing, it is reported (Report 2012a) that it became increasingly difficult to access water sharing facilities and therefore timely implement water releases and transfers. While the Uzbek side continued to insist on the 50/50 allocation from the system, the Kyrgyz side insisted on the 82/18 sharing as per Protocol (1980). It is also reported that there was no water incoming in the Maylisai river to Uzbekistan in August of 2011 (Letter 2011). Report of Andijan province WMD show an overall decline in water received annually by Andijan province. With increasingly difficult access to transboundary infrastructure, more recent correspondence shows the implicit acceptance of the Uzbek side to receive at least 18% (Letter 2011), while there is still no clear agreement on whether the sharing refers to the entire system.

Case study 2. Sokh, Isfayramsai and Shakhimardansai rivers: incremental changes

Although early negotiations and agreements on the Sokh, Isfayramsai and Shakhimardansai rivers had different paths, at present they are shared between the same two jurisdictions and considered as one package due to their geographic proximity and transboundary nature. The case study looking at these three rivers will therefore detail

both the earlier differences and later similarities. How riparians renegotiated their shares on these rivers in the long run might be characterized as incremental changes.

All three rivers originate in Batken province of Kyrgyzstan and are shared with Ferghana province of Uzbekistan. It should be noted that until 1999 Batken province was part of Osh province, too. With an average annual runoff of 1368 million m^3 (43.4 m^3/s), catchment area of 3510 km^2 and length of 124 km, Sokh is the largest among all STTs in the Ferghana Valley (Chub 2007; CAWater-Info 2016). The average annual runoff of the Isfayramsai is 615 million m^3 (19.5 m^3/s) (about 50% of the Sokh river) (length - 122 km, catchment area – 2200 km^2) and the average annual runoff of the Shakhimardansai is 308 million m^3 (9.77 m^3/s) (about 25% of the Sokh river) (the length – 112 km, the catchment area – 1300 km^2). Within Ferghana province, these three STTs intersect with main canals. The flow of the Sokh is diverted to the tail-end of South Ferghana Canal (SFC) and Big Ferghana Canal (BFC). The Isfayramsai and Shakhimardansai intersect with the SFC. In all cases, this creates a mixed system within Ferghana province, relying on different water sources.

The three formal changes in the riparian shares within the Sokh STT that took place in 1973, 1980 and 1989 were in strong connection with the construction of the larger Toktogul and Andijan reservoirs (Protocols 1973, 1980, 1989). In the early 1960s, an expansion of irrigated agriculture in the Burgandy massif in Kyrgyzstan was seen as a compensation for the lands provided for the construction of the Toktogul reservoir (Memorandum 1986). Later, two projects were specified during the negotiations between the Kyrgyz SSR and Uzbek SSR to boost water supply in the Burgandy massif: (1) Left-Shore Kampyr-Ravat (LSKR) Canal with planned water transfers from the Andijan reservoir and (2) Sokh reservoir directly on the Sokh river (Protocol 1965).

In anticipation of increased water supply from the LSKR Canal and Sokh reservoir, the Kyrgyz SSR had already expanded its irrigation networks in the Burgandy massif. However, there were continuous delays with two projects. According to correspondence from 1979 (Letters 1979), the Kyrgyz SSR started unilateral withdrawals from the Sokh to implement its ever since increasing expansion (Figure A1). It resulted in sharp water shortages for the lands in Ferghana province. To mediate the dispute, the Uzbek SSR reassured its commitment to continue both projects and agreed to a 10/90 ratio for the Kyrgyz and Uzbek SSRs respectively (Protocol 1980). In 1981, the riparians reinforced the agreement of 1980 by specifying decadal allocations in line with the 10/90 sharing (Protocol 1981).

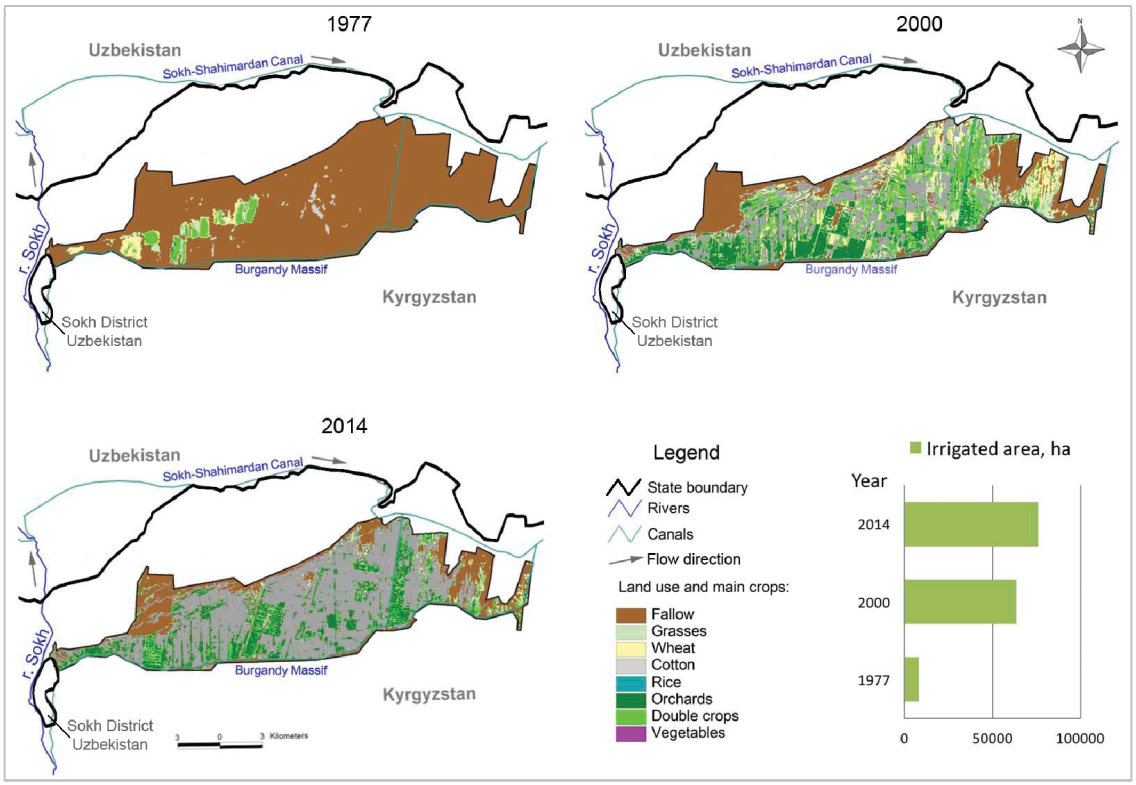

Fig. A1. Irrigation expansion in the Burgandy massif, upstream of the Sokh river in 1977, 2000 and 2014 (the selection of years is restricted by availability of data). Source: authors' own illustration based on data obtained through remote sensing.

The approval of the LSKR Canal by Moscow had a long delay and consequently was rejected as inefficient and the Kyrgyz SSR continued to demand further increase of its share from the Sokh river. In 1989, the new Protocol was signed to increase the share of the Kyrgyz SSR from 10 to 23% or more than 200 million m^3 of additional water annually. Although the new share of the Kyrgyz SSR exceeded its previously agreed share linked to the LSKR Canal, the construction plan of the LSKR Canal itself was not called off. The same Protocol (1989) documents the agreement between the riparians to pursue both the LSKR Canal and Sokh reservoir further.

The only formal change in allocation within the Isfayramsai and Shakhimardansai STTs (Protocol 1980) was a result of the separation of allocation on these STTs from the larger Karadarya basin. The argument of the Kyrgyz SSR was that when calculated jointly, lands under the larger Karadarya (3.9 km^3) would significantly absorb these two relatively small rivers. The Kyrgyz SSR argued that such calculation was inequitable since even a small water deficit in the Karadarya would result in significant shortages within these two STTs. The earlier principle agreement on separate accounts was reached in 1961 (Protocol 1961) and reiterated in 1964 (Protocol 1964). However, there was uncertainty on the exact and combined effect from ongoing projects around the valley (e.g. larger Toktogul and Andijan reservoirs, smaller Karkidon and Papan reservoirs). These projects had a direct impact on water allocations for these two STTs. As part of the negotiations on the Andijan reservoir, it was anticipated to expand the

irrigated area within the two STTs in the upstream Kyrgyz SSR by 6500 ha (Protocol 1965). Only in 1980, an agreement with exact shares for the two STTs before their intersection with the South Ferghana Canal (SFC) was reached (Protocol 1980). In 1981, in a bundle with the Sokh, the agreement on these two STTs was also reinforced with specifying decadal allocations (Protocol 1981).

After independence, the sharing arrangements on the three rivers suffered several shocks of different nature. The collapse of the Soviet Union led to hyperinflation in Uzbekistan. Consequently, the funds allocated for the construction of the Sokh reservoir depreciated and resulted in the seizure of the works. Only in 1993 renewed the Uzbek government its commitment to the project, however, highlighted that the funds would be disbursed to complete the resettlement works only (Letter 1993). In 1999, Batken district of Osh province was upgraded to province status. Report (2012b) from the Ferghana province WMD states that Batken province has increased unilateral withdrawals from all three STTs and that during the drought year of 2001 in January, February and March the STTs were completely blocked by Batken province. An emergency meeting on a Deputy-Prime-Minister level of both riparian states resulted in an oral agreement to share the water resources on each of the three STTs on 50/50 basis. However, the Ferghana province WMD Report (2012b) highlights that even this oral agreement was often not followed by Batken province. The data on the received flow by Ferghana province (Figure A2) seem to confirm both the decrease in 2001 and the subsequent downwards slope in trends for the Isfayramsai and Shakhimardansai, while the implementation of the 50/50 agreement on the Sokh appears highly unlikely.

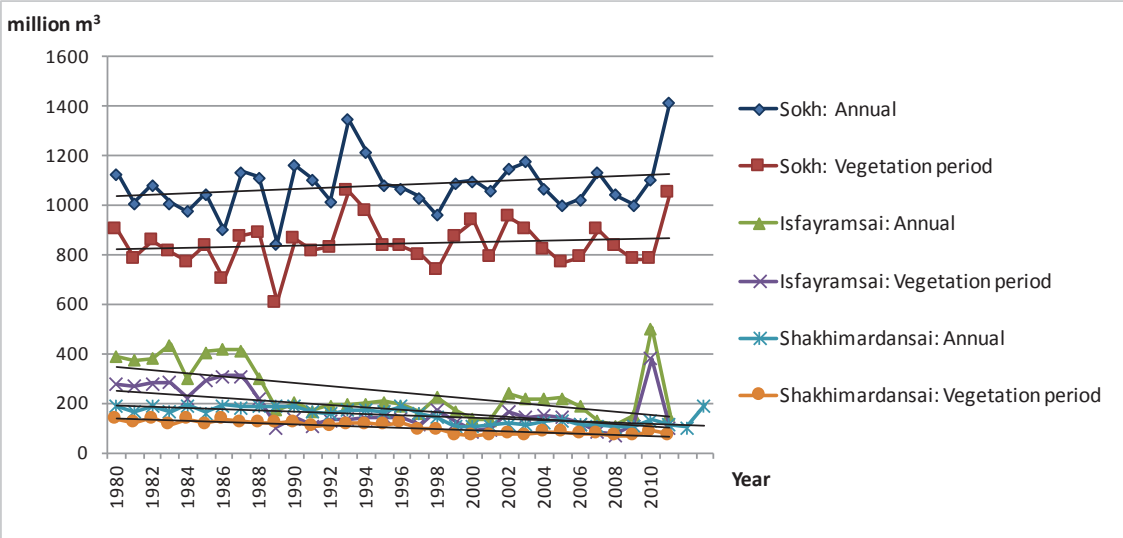

Fig. A2. Annual water received by Ferghana province from the Sokh, Isfayramsai and Shakhimardansai rivers in 1980-2011. Source: authors' own illustration based on reports of the Ferghana province WMD.

Case study 3. Isfara river: fundamental change

In the Isfara Basin, the long-term sharing arrangements have seen how a riparian state from being one of the two primary recipients of water from the river in earlier periods has come to be excluded in more recent allocations as a riparian altogether.

The Isfara river is shared by three riparians – Batken province of Kyrgyzstan, Sogd province of Tajikistan and Ferghana province of Uzbekistan. The river originates in Kyrgyzstan, flows through Tajikistan (Vorukh enclave), re-enters first Kyrgyzstan then Tajikistan and finally enters into Uzbekistan. The river has a diversion canal to the Tortgul reservoir, which flows through territories disputed by the states. The Tortgul reservoir in Kyrgyzstan has two outflows: either to irrigate lands in Batken province or to direct the flow back to the Isfara. Within Uzbekistan the Isfara feeds the Big Ferghana Canal (BFC) which has its tail-end in Tajikistan (Figure A3). The Isfara is 130 km long and has an average annual runoff of 351 million m^3 (11.1 m^3/s).

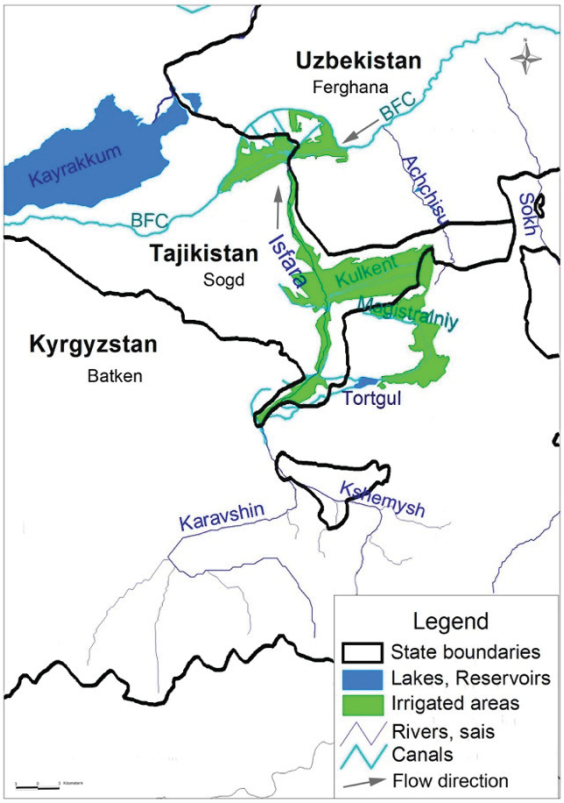

Fig. A3. Transboundary settings of the Isfara river. Source: authors' own illustration.

The first agreement in 1946 (Protocol 1946) was concluded to clarify the shares of the riparians during the vegetation period (Pak et al. 2014). The shares were defined as 2%, 48% and 50% for the Kyrgyz, Uzbek and Tajik SSRs respectively based on the existing allocations at the time. Following the reconstruction of the BFC which should have

increased supply for the Uzbek part of the valley, the shares were modified in 1958 (Protocol 1958) to 2%, 41% and 57% respectively.

While the Tajik and Uzbek SSRs continuously re-negotiated their shares on the river to incorporate changes in infrastructure and irrigated lands, the Kyrgyz SSR bypassed its downstream riparians and directly approached Moscow requesting approval for construction of the Tortgul reservoir (Pak et al. 2014). The Kyrgyz SSR received the approval and constructed the reservoir in 1971. The first request to re-consider allocations on the Isfara by the Kyrgyz SSR was documented in 1974 (Letter 1974). The argument was based on a general claim that the larger Toktogul and Kayrakkum reservoirs would provide increased water supply to downstream riparians (Letter 1974). In addition, the Kyrgyz SSR argued that the Isfara was the only source for expansion in the area while downstream provinces of the Tajik and Uzbek SSRs had more flexible arrangements through the BFC (Letter 1974). The Tortgul reservoir began its operation in 1975 and the Kyrgyz SSR started major unilateral diversions in the late 1970s. Furthermore, the Kyrgyz SSR argued that the delays in the construction of the LSKR Canal should have been compensated by increased shares in the Isfara, too (also see the Sokh case in the previous section). To compensate the loss, downstream Ferghana province had to construct multiple pump-stations which would lift water from the BFC (Pak et al. 2014). However, the reports from the Ferghana province WMD noted that there were at least 4000 ha solely dependent on the Isfara as they were located in the areas to which water could not be lifted from the BFC (Reference Certificate 2006).

A significant change in shares was documented with Protocol (1980) which connected all STTs in the valley and was prepared by the design institute Sredazgiprovodkhlopok. The new shares were 37% for the Kyrgyz SSR, 8% for the Uzbek SSR and 55% for the Tajik SSR. However, the Tajik SSR did not participate in the meeting and the Uzbek SSR did not approve the change. Two months later all three riparians agreed on a new arrangement as 17%, 35% and 48% accordingly. All changes were enabled through diversions to the Tortgul reservoir. The downstream Tajik and Uzbek SSRs had to adjust their shares accordingly which was close to 50/50 of the remainder after extracting the Kyrgyz share. In 1982, the new principle made it 22%, 38% and 40%, while Protocol (1991) assigned shares as 33%, 33% and 34% for the Kyrgyz, Uzbek and Tajik SSRs respectively.

After independence, as Pak et al. (2014: 9) report, the "allocations 'worked' for some time […], but later they became irrelevant". The BFC could no longer guarantee timely water deliveries in connection with the 1998 Syr Darya Framework Agreement on the Toktogul reservoir. The idea of the Framework Agreement was that Uzbekistan and Kazakhstan would compensate Kyrgyzstan for storing water in the Toktogul in winter and releasing it in summer through energy transfers. As the Framework Agreement was operational, there is no record of Tajikistan having paid or compensated for the releases

from the Toktogul. Therefore, it is assumed that Tajikistan could not claim water from the BFC. When the Framework Agreement stopped operating, Kyrgyzstan completely switched to the energy mode and less water from the Toktogul during the vegetation period meant less water at the tail-end of the BFC for Tajikistan. Consequently, Tajikistan has stopped water supply to Uzbekistan on the Isfara by diverting the Isfara directly into the BFC within Tajikistan. Fluctuations in water received by Ferghana province from 2001 through 2010 show the ad hoc nature and unreliability of the incoming flow (Pak et al. 2014). The analysis of Pak et al. (2014: p.12) conclude that although "the exclusion of Tajikistan from the BFC and the exclusion of Uzbekistan from the Isfara could be seen as a worst-case scenario in a conflict-and-cooperation matrix, in fact this scenario seems to be the most stable solution, given the dependence on alternative water resources from 'third parties' (the operation of Toktogul reservoir) and the political costs of brokering annual agreements".

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6 Synthesis and Outlook

The thesis has examined the question of to what extent benefit sharing approach is applicable to address *the need for* and *implications of* riparian water reallocation through a multi-level institutional analysis of case studies from the Ferghana Valley in the Syr Darya basin. This chapter presents the synthesis of the main research results, discussion of their significance for the state of the research and outlook on further research as organized in the following sections.

6.1 Synthesis of results

The main chapters of the thesis (Chapter 2-5) complement one another by examining different but interrelated aspects of benefit sharing application in transboundary water management. The highlights from the main chapters are presented in Table 6.1.

Table 6.1. Summary of the main chapters

Chapter	Framework	Methods	Scope	Major highlights
Chapter 2	Conceptualizing the costs of benefit sharing in transboundary water management	In-depth qualitative content analysis	Ferghana Valley, Syr Darya basin, Central Asia	Institutions affecting the transboundary water management and four groups of costs of benefit sharing identified
Chapter 3	Water security	In-depth qualitative content analysis, case studies, interviews with key informers	Ferghana Valley, Ferghana province, Syr Darya basin	Supply side water security identified as a weak point in the basin
Chapter 4	Idealistic versus realistic approaches, Costs and time horizon in transboundary water management	In-depth qualitative content analysis, quantitative analysis of operational and maintenance costs	Ferghana Valley, Ferghana province, Syr Darya basin	Links between lift irrigation and wider benefit sharing established, highly unsustainable operational costs identified
Chapter 5	Path dependency in riparian water reallocation	In-depth qualitative content analysis, three case studies	Ferghana Valley, 5 small transboundary tributaries of the Syr Darya river	Key sources of path dependence determining reallocation efficiency identified

Further, the cumulative findings of the research are synthesized through answers to three main questions: (1) *What is the impact of institutions on benefit sharing?* (2) *What is the impact of benefit sharing on water security and cooperation?* and (3) *What are the key sources determining the degree of change in reallocation?* Answers to these questions form the following three sub-sections.

6.1.1 What has been the impact of institutions on benefit sharing?

As a result of analysis, five distinctive periods of benefit sharing have been distinguished, where significant shift in establishment of institutions took place affecting the way benefits and costs from cooperative developments are shared among the riparians in the Ferghana Valley:

- During 1917-1953 although the republics had only a symbolic autonomy in decision-making, developments which would have crucial impacts on the types of benefits and the way those benefits would be shared later. Key institutional developments affecting benefit sharing within this period: (1) future decision-making bodies were established through republican border delimitation; (2) foundations were created for property rights on land and infrastructure; and (3) strategic priority was set to achieve cotton independence.

- The year 1953 marked the end of the Stalin period. Although the new leadership of the Soviet government continued with further policies to increase agricultural output, there were the following important differences influencing various aspects of benefit sharing: (1) republics received more autonomy in decision making; (2) negotiations resulted in numerous asymmetric issue linkages; and (3) issues were linked both within and outside the basin.

- In 1970, the future of benefit sharing was significantly influenced by two important developments. The 1970 Order from Moscow fuelled competition between the republics and the 1970 Law on Water called for integrative basin approach. Key institutional developments: (1) proportional water allocation principle; (2) competition for irrigation expansion increased between the republics; and (3) issues were linked outside water sector.

- By 1980, most of the larger infrastructure had been completed and there was a need for new sharing arrangements taking into account all the changes. The following four significant developments were found which shaped the new period of benefit sharing: (1) increased complexity of issue linkages; (2) amplified autonomy in decision making and negotiation; (3) further expansion and basin closure; and (4) increased cooperation and lost tracks of linked issues previously.

- The final period is between 1991 and 2013. From institutional perspective to benefit sharing, the most important distinction of this period is that the republics found themselves between the highest level of autonomy in decision making (sovereignty) by far on the one hand, and the highest level of physical interdependence (shared resources and infrastructure) on the other hand. It resulted in the following key institutional developments affecting the relationship: (1)

difficulties in border-crossing slowed down the intensity of cooperation; (2) financial difficulties led to isolated focus, fragmentation and break of linkages; (3) emphasis on environmental protection did not reflect on lower levels; (4) small transboundary tributaries and provinces were left out of broader picture.

The impact of the established institutions on benefit sharing is summarized in Table 6.2.

Table 6.2. Summary of the periods on institutions and benefit sharing

Periods	Institutions established	Benefit sharing	Mechanisms	Benefits		Risks and costs
1917 - 1953	Republican borders, property rights on land and infrastructure (Level 2 – Williamson 1998)	Existed only technically (not voluntarily), founded the shared infrastructure	Command and control from central government	Type 2 and 4	Increased through boost in smaller infrastructure, pasture exchange	Equity related – massive use of forced labor Environmental consequences not considered
1953 – 1970	Autonomous negotiations (Level 2 institutions), irrevocable commitments linked with revocable ones	Emerged with initiation of larger shared projects, autonomous bilateral negotiation, specific shares of each republics	Monetary and non-monetary compensation, issue linkages within and outside water sector, across basins	Type 2 and 4	Increased through boost in larger infrastructure, pasture exchange, more cooperation overall	Equity related – gradual improvement towards local population and local governments Pressure on environment increased Complexity increased Asymmetric issue linkages increased
1970s	Proportional allocation principle tied to irrigated areas (Level 3 institutions), competition for expansion	Existed and challenged by further autonomy of republics, increased claims of the late developer	Monetary and non-monetary compensation Issue linkages within and outside water sector	Type 2 and 4	Increased through basin scheme to use the basin resources to their fullest, more cooperation	Equity related – moved to background with focus on implementation Environment - no priority in the Scheme Disagreements increased with asymmetric issues
1980 – 1991	Governance institutions (Level 3 institutions): managing through sub-basin allocations	Strengthened by further autonomy and official disputation of the Moscow's decisions	Non-monetary compensation, issue linkages within and outside water sector	Type 2 and 4	Increased through basin closure, rise in pump-stations, more cooperation and disagreement	Equity related – increased with implementation issues Pressure on environment saturated with basin closure Complexity increased with new package deal Sides used their riparian positions more often
1991 – 2013	Level 1 (traditions, customs, norms) and Level 2 institutions (above) carried over, Level 3 partly valid, Level 4 (allocative efficiency) attempted by national reforms, still in process	Encouraged and tested on national level but failed (1998 Framework Agreement), practiced on meso level (linked infrastructure), being replaced by national solutions	Issue linkages within and outside water sector	Type 2 and 1	Partly maintained through operation and maintenance of existing infrastructure, enhancement of flood control	Equity related – more disagreements on sharing principles Environment – not implemented on lower levels Complexity – break in issue linkages due to border crossing problems and lack of technical, financial capacities Sides used their riparian positions

6.1.2 What has been the impact of benefit sharing on transboundary water security and cooperation?

First, benefit sharing indeed boosted opportunities to cooperate as was promoted by Sadoff and Grey (2002), Phillips et al. (2008) and others, even in cases when parties had difficulties to agree on the quantities.

Second, in addition to direct operational and maintenance costs (Chapter 4), four risk categories resulting in indirect costs have been identified (Chapter 2) (Table 6.3.). The most challenging risk is setting environmental benefits from cooperation as a priority (Risk 1, Benefit Type 1). This was problematic even with the existing understanding within the international donor community as well as on the highest level within the countries. Shorter-term benefits (Benefit Types 2, 3, 4) such as reaching an agreement on mutually beneficial additional storage capacities or committing to exchange favors on different issues were more appealing. The higher-level impacts on transboundary water security and cooperation (Chapter 2, 3) might be attributed to the other three categories of risk. Equity related risks (Risk 2): increased and accumulated dissatisfaction with the way benefits are shared led to higher-level failures in the long-run. Risk related to complexity: (Risk 3) issue linkages grew to a level when monitoring real time implementation became either impossible due to lack of capacities or unsustainable due to high costs (with direct operational and maintenence costs). As a result, uncertainty and insecurity triggered opportunistic incentives occasionally leading to misuse of asymmetric issue linkages (Risk 4) intensifying disagreements.

Table 6.3. Impact of benefit sharing on long term water security and cooperation

Periods:	**1917-1953**	**1953-1970**	**1970s**	**1980-1991**	**1991-2013**
Benefit Sharing and Benefits					
Type 1 – Environmental	not found	not found	not found	not found	⇧
Type 2 – Economic	⇧	↑	↑	⇧	↓
Type 3 – Political	↑	⇧	⇧	⇧	↓
Type 4 – Catalytic	⇧	↑	↑	⇧	↓
Risks of Benefit Sharing and Costs					
Risk 1 – Equity related	↑	⇧	⇧	↑	↑
Risk 2 – Environment related	⇧	↑	↑	↑	⇧
Risk 3 – Complexity related	⇧	⇧	⇧	↑	↑
Risk 4 – Power related	⇧	⇧	↑	↑	↑
Risk 5 – Direct operational costs	⇧	⇧	↑	↑	↑

LEGEND

Trend	**Implications for Cooperation in the Long-Run**
↑ Strong growth	■ creates largely opportunities for cooperation
⇧ Moderate growth or decline	□ creates both opportunities & challenges for cooperation
↓ Strong decline	■ creates largely challenges for cooperation

Source: adapted from author's presentation at the 7th International Conference on Water Resources and Environment Research (Soliev et al. 2016)

Benefit sharing did help facilitate negotiation and achieve win-win solutions. However, focusing on short-term opportunities made future negotiations less effective. Accummulated tension in risk categories burst during later negotiations leading to disagreements on various degrees. Hence, should achieving transboundary water security pursue solutions stable in the long-run using benefit sharing as a tool, its risks and costs must be taken into account.

6.1.3 What have been the key sources determining the degree of change in reallocation?

Given the economic rationale of benefit sharing to reallocate water to more beneficial uses, the thesis examined three different cases along the continuum of path dependence (Chapter 5) to identify how drivers of pressure pushing towards reallocation interacted with sources of path dependency resisting to reallocation. It has been established that development needs, financial shocks and climatic changes have been the main drivers of pressure to reevaluate past agreements and reallocate transboundary water resources. However, the institutional analysis revealed that the degree of change in reallocation was largely determined by interplay of three sources of path dependency:

(i) Vested interests: institutionalization of water as a source of (economic) benefits creates opportunistic incentives; a riparian with established entitlement resists to reallocation affecting its share or benefits negatively;

(ii) Infrastructure control: infrastructure built for implementing allocation decisions create a long-lasting control over water; control over infrastructure enables its holder(s) to implement unilateral decisions;

(iii) Network effects: physical and institutional complexity of the system within and across jurisdictions make it difficult to undertake partial reforms without undertaking reforms to the entire network: (a) multiple governance levels and scales of administrative reforms, (b) physical interdependence of infrastructure, (c) issue linkages within agreements make up the network effects and (d) lack of information and knowledge intensify them.

The universal positive feedback proved to be from vested interests as an incentive of ‘getting more water’ was institutionalized within the proportional sharing principle. The strongest manifestation of vested interests took place when large infrastructure granted control, and network effects (complexity) provided reason for implementation of unilateral plans. Network effects came out to be as the most decisive driver, strong network effects led to persistence of delay in implementation of reallocation over long

time (Chapter 5 – Case study 1: Maylisai river). The partial and gradual separation of issues and therefore reduced network effects resulted in corresponding incremental reallocations (Chapter 5 – Case study 2: Sokh, Shakhimardansai, Isfayramsai rivers). It was when existing issues in bundle were delinked both physically and institutionally, the fundamental change leading to exclusion of riparians took place (Chapter 5 – Case study 3: Isfara river).

6.2 Discussion: a critical appraisal of benefit sharing in managing shared water resources

The analysis of the dynamic negotiations over shared water resources in the Ferghana Valley as presented in Chapter 2 through 5 demonstrates that benefit sharing provides an enabling platform for facilitating transboundary water cooperation and security. However, it shows that implementation of the agreed arrangements is problematic in the long-run when focus is on benefits. The thesis investigated four such weaknesses of benefit sharing.

First, as Chapter 2 demonstrates, implementation of benefit sharing is prone to failures due to indirect costs which might make any subsequent round of negotiations less effective. These indirect costs include: (1) those related to equity of sharing both internationally and locally; (2) costs to the environment; (3) costs resulting from increased complexity of issue linkages; and (4) costs as a result of misuse of asymmetric issue linkages. To the knowledge of the author, the study presented in Chapter 2 is the first which holistically looks into costs of benefit sharing in transboundary water management. It expands works of Hensengerth et al. (2012) who looked at benefit sharing in dam projects, Tarlock and Wouters (2010) at equitability of sharing and environmental effects, Dombrowsky (2009) at property rights and Dombrowsky et al. (2014) at international and local aspects of benefit sharing. More broadly, the findings of Chapter 2 with indirect costs and Chapter 4 which details direct operational and maintenance costs over time are interesting in the sense that they provide clear empirical evidence of how ‘cooperation’ could lead to unwanted results on massive scales. Gillinson (2004: 31) providing an interdisciplinary analysis of the question “why cooperate?” states “encouraging cooperation is often a problem” because “we are often too intent on short-term gain to see the ultimate cost”. However, having stated that, Gillinson (2004) goes on to conclude that cooperation is still a necessity for efficiency and survival of social systems. Details of such debate would go beyond the scope of this study; however, with few exceptions which look at “the other side of cooperation” in the discourse of transboundary water management (e.g. Zeitoun and Mirumachi 2008) it is a clear weakness that costs of cooperation have by far received little attention. Whether costs are integrated or ignored, as Chapters 2 and 4 show, is

detrimental for both efficiency and survival of the cooperation, exemplified here in the form of a wide range of various agreements with shared benefits.

Second, Chapter 3, looking at the state of water security in the Syr Darya basin, reveals that neither polycentric water management nor water supply organizations have received broad international attention in the basin. Instead, the focus has been on the creation of the water user associations (WUAs) at the local level and most of the benefit sharing approaches at the international level focused on basin management and larger reservoirs such as the Toktogul and Kayrakkum. As a result, there is a missing link, which in the past, as Chapter 2, 4 and 5 also show, have been the province water management departments and this essential element of water supply security has been either taken for granted or overlooked. Broader implication of the study relates to the discussion of the reductionist versus integrative approaches in research to the complex water security policy challenges (Zeitoun et al. 2016). The often assumed simplification is to look at the Syr Darya basin as a river basin shared by four countries and therefore four users with certain infrastructure to regulate the flow of the Syr Darya. The complexity in the basin is reduced and an optimization model can allocate water in a most beneficial way among the users (in this case four countries). Such analysis indeed helps simplify the decision-making process. However, the simplification of complexity, as the analysis of the details in Chapter 3 demonstrates, leads to loss of vital elements that need to be taken into account to achieve effective water security. Simplification is in fact highly likely why many projects in the Valley with isolated focus did not succeed as expected. Bigger donors such as the World Bank, Asian Development Bank and United States Agency for International Development (Teasley and McKinney 2011; Bichsel et al. 2011; UNDP 2004) focused on the larger rivers without going into details of the lower level interdependencies. The initiatives of the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) on the Isfara and Khodja-Bakirgan STTs (Bichsel et al. 2011; Djaylobaev et al. 2014; UNDP 2004) focused on signing bi-lateral agreements, which led to exclusion of Uzbekistan from the Isfara STT (Chapter 5 of this thesis; Pak et al. 2014). The projects of the Swiss Agency for Development and Cooperation (SDC) on the Shakhimardansai and Khodja-Bakirgan STTs (Bichsel et al. 2011; UNDP 2004), although focused on bottom up cooperation, did not succeed due to a weak link up with higher frameworks (Yamaswari et al. 2015). Further broadly, this can revitalize the debate in research where methods of grounded theory are contrasted to those of thematic analysis. How much one needs to know about the study area to apply thematic analysis so that important elements of the problem structure are not lost?

Third, Chapter 4, building on the findings from Chapter 2 and 3, demonstrates how important it is to consider direct costs of benefit sharing. While the current international literature on transboundary water resources in the Syr Darya basin suggests that historically only downstream benefited from the large upstream reservoirs and therefore should pay for services provided today, the case study has highlighted that this focus is one-sided. The case study has brought forward that operational and maintenance costs of other infrastructure such as pump-stations built to cope with massive irrigation

expansion upstream as examined in the case-study should be considered. In the example of Ferghana province, integrating these costs into the analysis already shows that while benefits were shared across the borders, which in fact significantly increased for upstream Kyrgyzstan over the past 40-50 years, costs, which have been increasing over time, were borne primarily by downstream Uzbekistan. Nearly 30% of province water department expenses annually were to cover operational costs of pump-stations built to compensate losses due to the upstream expansion. Furthermore, given that the pump-stations lifted water from canals with intake from the Naryn, with the change of the Toktogul reservoir's operation to energy mode which regulates the Naryn, even this source became highly unreliable. Thus, Ferghana province found itself paying twice for its share of benefits, and the perception that downstream should pay more is still there. An interesting broader discussion is whether cost sharing (e.g. Moretti et al. 2016) would be a more stable approach rather than benefit sharing. When costs are shared and under scrutiny, it should be safe to assume that one would hardly ignore benefits, hence, both benefits and costs are considered. The opposite is, however, as reiterated multiple times, not true: costs tend to be ignored when focus on benefits and benefit sharing. Nevertheless, the 'problem' of cost sharing is that it might not encourage cooperation as much, especially when riparian states are already interested in cutting expenses and not increasing them.

Fourth, Chapter 5, dealing explicitly with the question of implementation, identifies what sources of path dependency determine the degree of change. As the chapter explains, the level of existing socio-economic and techno-ecological development in a river basin does influence how reallocation will take place. The institutional analysis revealed that the degree of change in reallocation was largely determined by interplay of three sources of path dependency: (i) vested interests, (ii) infrastructure control and (iii) network effects which form the 'baggage' in riparian relationship. The success of reforms, negotiation and implementation of new allocation decisions will greatly depend on how well these processes take into account the unresolved issues and pent-up pressure. The economic rationale of benefit sharing is to reallocate water to more beneficial uses both to meet growing demands and to transform conflicts into cooperation. In this context, knowledge about the riparian position along the continuum of path dependency as well as on the interplay of key sources of path dependency will be necessary to make the formal reallocations effective. The findings of the study highlighted the central role of clarity in knowledge and hence improving technical and personnel capacities, and the need for caution in respect of reforms intensifying network effects which in the long run increase complexity and make the system highly prone to financial and climatic shocks. This is especially important as benefit sharing approach calls for higher levels of linkages within and across jurisdictions and issues in transboundary basins (Sadoff and Grey 2005).

Assuming vested interests present as they were in our cases, where an upstream riparian has development needs/ambitions related to shared water resources, infrastructure upstream and being in unilateral control of the infrastructure appears to be a general risk

for stability in relationship of riparians with 'baggage'. This phenomenon can be proven also in other parts of the world, such as in the recent advances in the construction of the Grand Ethiopian Renaissance Dam in the Nile which made Egypt negotiate with Ethiopia (Tawfik 2015). The accumulated pressure from long-standing disagreements with no or little change resulted in a fundamental change. Looking further broadly, the lack of ultimate overarching authority in a transboundary setting – arguably the most challenging feature of transboundary water management – makes dialogue and whether one can persuade other riparian(s) as well as international community increasingly important for how much resistance intended reforms will face. "Soft power of persuasion" described by Zeitoun et al. (2011: 159) comes into play. However, while persuasion implies that there is a side to be persuaded, network effects simply provide unilateral justification, meaning without the need to persuade the opponent. Persuasion implies that action follows explanation, the danger in case of network effects is that it is the opposite: explanation follows action. Then, the question of whether upstream honors an agreement or not increasingly becomes a matter of justification, amplifying the uncertainty for downstream with each infrastructure project upstream. Therefore, it might be understandable that countries downstream are often opposed to upstream large-scale infrastructure and generally prefer smaller incremental changes.

Finally, it is fascinating how sufficiently strong network effects, where riparians are in need of development but do not have technical capacities to fully monitor water flow, can create conditions inherently unfavorable to trust. Even when a riparian receives less water due to natural variability, the accumulated 'baggage' in relationship can easily push this riparian towards defensive strategies. This riparian will have to compensate its 'loss' from other sources or in other ways altogether (through arrangements in other sectors) due to pressing development needs since efficient negotiation is highly unlikely. That, in turn, will most likely have reciprocal consequences leading to an endless domino effect. Hence, it appears that establishing the full technical control of runoff – transparent measuring infrastructure allowing instant flow of data for all sides and continuity of highly professional staff – should be of highest priority and starting point in cases with rich history of relationship and aging infrastructure. Improving clarity of data should be followed by achieving absolutely clear decisions on validity of historical agreements. Only when the data and rules are not constantly contested, reallocation in an environment of high institutional and geographic complexity becomes implementable in an effective way.

6.3 Outlook

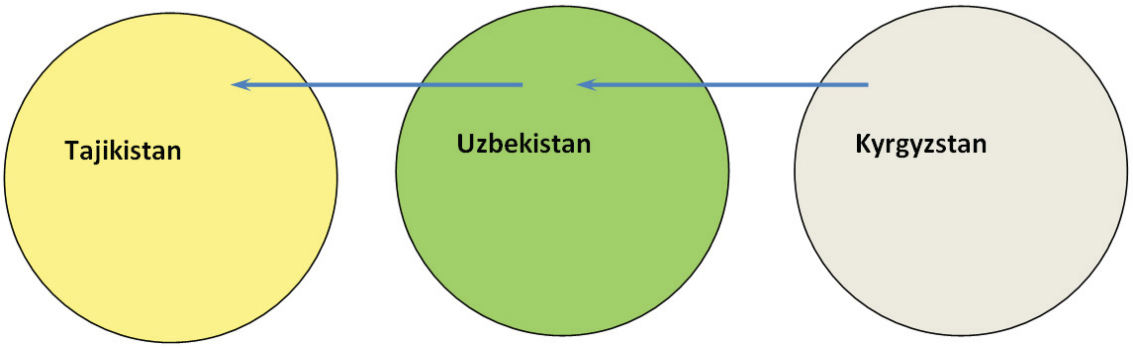
The research presented in this thesis could be extended in a number of ways. Here, potential topics for future research in relation to transaction costs, negotiation as well as conflict and cooperation discourse in transboundary water management are outlined.

First of all, the research could be complemented methodologically. While Chapter 4 has provided quantitative analysis of direct operation and maintenance costs in the example of one province, Chapter 2 has studied the indirect costs of benefit sharing and provided qualitative analysis of identified cost categories. Although Chapter 2 (p.36) explicitly notes that "it is questionable whether issues with this level of complexity and over such long period of time would allow quantifying costs and benefits with any accuracy at all", it would be desirable to explore further ways to quantify the costs and benefits on polycentric level, i.e. on the level of provinces. One way to do so, if for example a game theoretic approach is applied (e.g. Teasley and McKinney 2011), would be reframing the game structure to reflect the missing details such as number of actors and therefore possible interactions involved. Looking at the findings of the research (Chapter 2-5), a first step in such reframing would be to reconsider the often simplified water use schematic of the Syr Darya basin. An example of moving from reductionist to integrative approach (Zeitoun et al. 2016) is illustrated in Figure 6.1.

In such a setting, the obvious difference is that the number of players grows from 3 to 7 already within the Ferghana Valley (without considering the rest of the basin). Consequently, when details on the province level are integrated, the number of possible interactions and therefore strategies that could be applied by each player increases significantly. That could be further analyzed by attaching corresponding weights to each of the rivers based on their annual flow, infrastructure (reservoirs) and water use characteristics (for example, irrigated area). Quantification could be explored in terms of transaction costs. What would be implications of a change in the Toktogul's operation for each player? How many more agreements would require a review and amendment if parties reach a new agreement with isolated focus on the Toktogul reservoir?

Further transactions costs both described as static and dynamic (Marshall 2013) could be estimated for shifting from the status quo to a coalition. Static transaction costs include added costs of "support and administration", "contracting", "monitoring and detection" and "prosecution and enforcement" related to new arrangements in a coalition. Dynamic transaction costs include (1) institutional transition costs which can be costs of research, negotiation, preparation and reaching a coalition agreement, hence, *ex ante* costs and (2) institutional lock-in costs which can incur as a result of transaction where for example new right holders might impose their terms and manipulate future distribution of costs and benefits from a coalition.

a) Reductionist approach:



b) Integrating polycentricity:

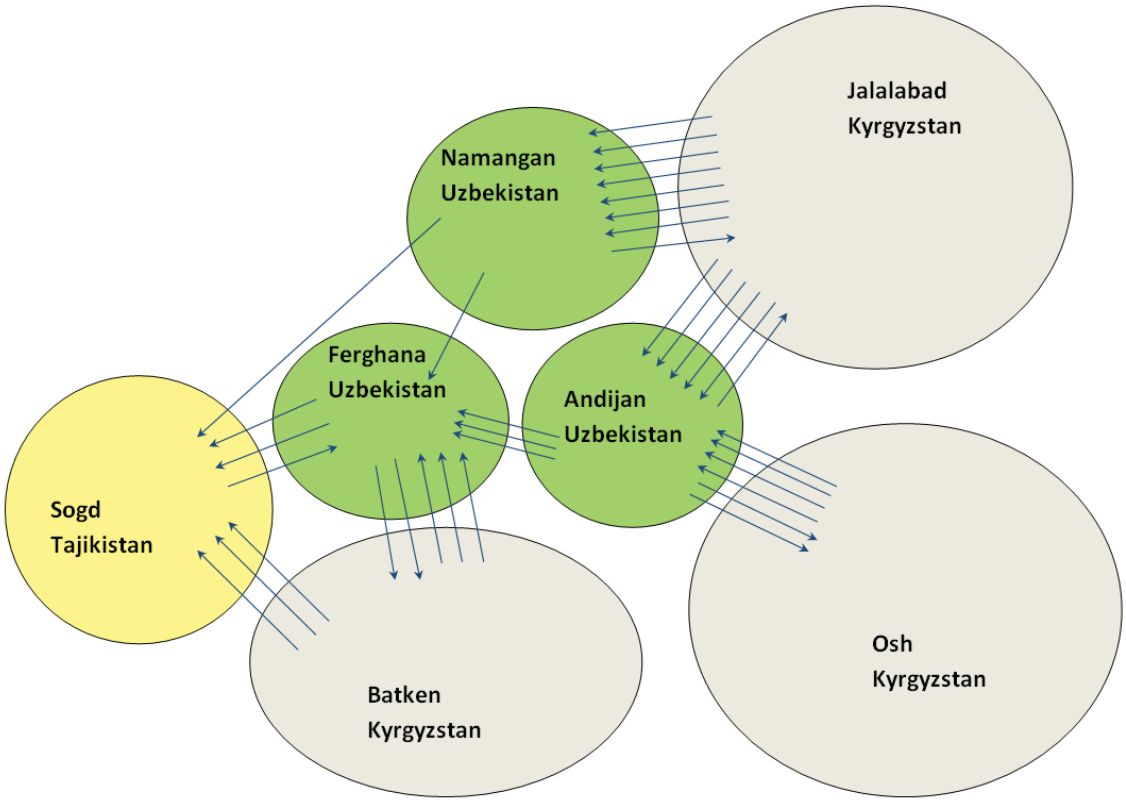


Fig. 6.1. Reductionist (a) and integrative (b) approaches in research to complex water security challenges in the example of the Ferghana Valley, the Syr Darya basin. Note: Oval figures represent water users and arrows denote rivers and their flow direction.

Using official data related to actual water releases from the reservoirs in the basin, costs and benefits in irrigation as well as energy sectors, costs of operation and maintenance for infrastructure, identified transaction cost categories can be estimated to provide

better insights why cooperation options as suggested by simple models (e.g. Teasley and McKinney 2011) are not realistic. A hypothesis would be that in the Syr Darya basin, the basin riparians have chosen pragmatic solutions because they are intuitively aware of wider costs. Results of such a research could contribute both to better understanding of optimization processes in transboundary water management in the Syr Darya Basin and more broadly to measuring transaction costs in highly complex socio-environmental systems.

It would be also worthwhile to expand the research by revisiting the negotiation aspect of benefit sharing in transboundary water management. The well-known mutual gains approach of Harvard negotiation project could be re-examined with restructuring its main objective from "getting to a yes" to "getting to a sustainable yes" (Fisher and Ury 1981). A very specific feature of shared water resources is that the object of negotiation physically binds the negotiating parties. In most, with the exception of very few, cases riparian states are connected with one another through shared water resources for good. That is not the case when negotiation is undertaken on other subjects such as trade, transportation, food, labor migration, etc. This means that interaction among riparian states is to some extent unavoidable. Hence, the priority should be placed not on one-time solutions rather on developing a long-term strategy that would allow stability in the relationship. In this context, the role of third parties – mediating states, development agencies, and donor organizations – which are often result oriented could be examined to understand whether and to what extent a long-term perspective could be integrated in negotiation.

A further "intriguing research question" as described by Pahl-Wostl (2009: 358) that could be applicable for extension of the presented research would be how to strike "an appropriate balance between permanence and change [?]". On the one hand, governance systems need a change to be able to adapt to changing circumstances. On the other hand, permanence is needed so that actors can plan effectively based on reliable expectations. Pahl-Wostl (2009: 358) goes on to conclude that "rather than a dominance of one governance mode a more diverse governance system has a higher adaptive capacity and will lead to more sustainable resource governance". Within the discourse of conflict and cooperation in transboundary water management, it has been questioned whether the two main principles of international water law "equitable and reasonable use" and "no significant harm" contradict each other and therefore whether they help facilitate cooperation (e.g. Wegerich and Olsson 2010). However, these two can also be seen as balancing principles. Generally, it is referred to "equitable and reasonable use" when a (upstream) riparian state contests the status quo allocation and demands a reallocation which will be more "equitable and reasonable". At the same time, it is often referred to "no significant harm" when a (downstream) riparian state insists to maintain the status quo and that reallocation should not take place because it would cause "a significant harm". The drivers of these opposing vectors might in fact help prevent both (a) a complete absence of a change and (b) a change from happening too

often. At the same time, findings of Chapter 5 have suggested three key sources of path dependency interplay among which determine the degree of change: from no or little to fundamental. Chapter 5 (137) concludes that "… an incremental de-facto change in water allocation which is in line with incremental formal changes might be more sustainable in the long-run". Against this background, research could be conducted to understand the potential of individual benefit sharing instruments as discussed in Chapter 1 and 2 (monetary and non-monetary compensation mechanisms, issue linkages within and outside water sector) to provide the necessary balance.

Finally, future research is needed to analyze needs of the riparian states to bring their personnel and technical capacities to the level required to process the existing institutional complexity. The thesis demonstrated the paramount importance of integrating costs (Chapter 2 and 4), polycentric and longitudinal perspectives (Chapter 2-5) as well as path dependency (Chapter 5) for sustainability of benefit sharing arrangements in the Ferghana Valley, the Syr Darya basin. While it is clear that mismatches within the complex institutional environment already set conflicting incentives and do not help new benefit sharing arrangements, weak technical and personnel capacities make it even harder to take into account the rich institutional nuances (Chapter 3 and 4). Successful integration of these nuances at the planning or negotiating stage of new benefit sharing arrangements will depend on whether one would engage comprehensively enough with analysis of existing institutional arrangements. In our case, such investigation required going back for around a century-long period in Chapter 2 and for around a half a century period in Chapters 3, 4 and 5. Obviously, outdated and aging infrastructure does not provide the necessary level of instant and reliable data and younger generations coming to higher positions lead to loss of important knowledge. Therefore, it is stressed that achieving full technical control over shared water resources and establishing continuity of highly professional staff particularly at the province water management departments will be decisive in making future benefit sharing arrangements successful.

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Statement of Contribution

The main parts of this thesis (Chapter 2-5) are the product of collaboration among the author, his advisor, Volkmar Hartje, and other researchers. The contributions of authors, particularly to framing questions, developing methods, conducting analysis, discussion of results and writing the articles are detailed below.

Chapter 2: Early discussions with author's advisor, Volkmar Hartje, provided insights to various perspectives of benefit sharing in transboundary water management. The author developed the initial and final versions of the framework, analyzed the data, organized the systematic discussion of the costs and led the drafting process of the study incorporating the contributions from co-authors as well as from his advisor and reviewers at International Water Management Institute. Kai Wegerich proposed the initial idea of testing the approach in case of the Ferghana Valley, contributed by interim editing of the paper, drafting the initial version of the discussion section, structure of the study and raising critical questions on the approach. Jusipbek Kazbekov contributed by providing his expertise and insights on the study area and historical-institutional arrangements as well as clarifications in understanding complications and connections of the collected data, facilitated the development of the updated map.

Chapter 3: Kai Wegerich developed the initial and final versions of the framework, analyzed the data, organized the systematic discussion and led the drafting process of the manuscript. He incorporated the contributions from co-authors as well as from reviewers. Daniel Van Rooijen provided substantial comments on the initial framework section as well as the initial version of the manuscript. The author and Nozilakhon Mukhamedova contributed by providing their expertise and insights on the study area as well as on transboundary arrangements as well as local level land and water reforms.

Chapter 4: Kai Wegerich suggested and led the research. He analyzed the initial data, identified the research questions and wrote the initial introduction, background, main parts of the case study section, discussion and conclusion. Kai Wegerich finalized the manuscript and was responsible for answering the review comments. The author contributed with discussions on benefit sharing, drafted the initial version of the framework and contributed to the case study section with the information regarding the transboundary agreements and prepared the graphs on operational costs of the irrigation department. The author commented and edited an interim version of the case study, discussion and conclusion sections. Indira Akramova investigated locations of pump-stations and their significance for transboundary water compensation and developed the maps.

Chapter 5: The author developed the initial and final versions of the framework, analyzed the data, suggested the concept of a 'baggage in riparian relationship' and wrote all parts of the article by incorporating contributions from the co-authors and reviewers. Insa Theesfeld shaped the logic of the paper, framed the main questions, suggested building on the continuum of path dependency and helped to fine tune the terminology. Kai Wegerich suggested the idea of longitudinal comparison of the case studies, raised critical questions and edited several parts of the earlier versions of the article. Alexander Platonov contributed to the case studies by analyzing geographic data and developing the necessary maps.

Tools and Resources

Typesetting. This document was prepared with Microsoft Word 2007, 2010 and 2016.

Figures were prepared with Microsoft Word and Excel 2007, 2010 and 2016.

Maps were developed using ESRI ArcGIS v. 9.3.1.