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Balancing the Discussion of Benefit Sharing in Transboundary Water Governance: Stressing the Long-Term Costs in an Empirical Example from Central Asia

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Abstract

Internationally the benefit sharing approach is promoted to encourage cooperation in transboundary water governance. Costs of cooperation are so far under researched. Attention of few international studies is limited to benefit and cost sharing practices for dam projects. Here, the case study looks at long-term costs of cooperation in an empirical example from Central Asia. In the Syr Darya Basin, a compensation package for constructing the Toktogul Reservoir on the Naryn in upstream Kyrgyzstan required Uzbekistan to shift water withdrawals from small transboundary tributaries to the main river. The shift of water allocation created long-term costs for Uzbekistan. The paper highlights the challenges related to the originally perceived as beneficial compensation mechanisms (water swaps) within one basin and long-term cost implications. The need for revision of benefit sharing agreements to allow adaptation to new challenges is discussed. We stress the costs when existing benefit sharing arrangements are ignored whether in full or in part.

Keywords: Transboundary water; Benefit sharing; Long-term costs; Pumping stations; Central Asia

1. Introduction

Benefit sharing (along with the nexus approach) has become the dominant discourse if probably not the practice in transboundary water governance (Philips Daoudy, McCaffrey, Öjendal, & Turton, 2006; Sadoff & Grey, 2002, 2005). The purpose of the approach is to achieve better cooperative arrangements based on greater incentives for riparian parties in a transboundary setting. However, while the concept mainly focuses on benefits and has a promotional nature to encourage cooperation, the term "costs" is not emphasized

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as much as the term "benefits" within the approach. Studies highlighting the long-term costs in a transboundary interaction are relatively rare (Dombrowsky, 2007; Hensengerth, Dombrowsky, & Scheumann, 2012; Soliev, Wegerich, & Kazbekov, 2015; Tarlock & Wouters, 2007), and it is generally difficult to illustrate these costs with more detailed longitudinal empirical data. Here, a study on Uzbekistan and Kyrgyzstan highlights costs of transboundary interaction aimed at achieving mutual benefits by looking at long-term implications of compensation mechanisms of various infrastructure projects in the Syr Darya, one of the two major transboundary rivers of Central Asia.

Since the early 1990s, Central Asian states chose different pathways for development while the nature of interconnected transboundary water resources keeps them dependent from one another. This makes the region one of the globally well-known cases where, as reported by many scholars, there is a strong need for improved cooperation (Abbink, Moller, & O'Hara, 2009; Antipova, Zyryanov, McKinney, & Savitsky, 2002; Dinar, Dinar, McCaffrey, & McKinney, 2007; Frenken, 2013; Granit et al., 2010; Keith & McKinney, 1997; Micklin, 2007; PA Consulting, 2002; Raskin, Hansen, Zhu, & Stavisky, 1992; Sharma, Markandya, Ahmad, Iskakov, Krishnaswamy, 2004a, Sharma et al., 2004b; United Nations Development Programme, 2009; United Nations Economic Commission for Europe, 2011). There is a growing attention to emphasizing the benefits of cooperation (Bekchanov, Bhaduri, & Ringler, 2015; Teasley & McKinney, 2011). A recent study goes as far as to estimate not only the benefits of cooperation but also the costs of inaction with the aim to encourage decision makers to act (Pohl et al., 2017). The cost sharing or costs of action are not emphasized proportionately. In addition, the international literature on benefit sharing in the Syr Darya Basin often focuses on large transboundary infrastructure such as the Toktogul and Kayrakkum reservoirs, located in upstream Kyrgyzstan and midstream Tajikistan respectively, and the modalities of their operation for midstream Uzbekistan and downstream Kazakhstan (Teasley & McKinney, 2011). The Syr Darya Basin Agreement of 1998 and 1999 focused on the operation of these reservoirs through energy exchanges (hydropower versus fossil fuels) (Stucki & Sojamo, 2012; Wegerich, 2004). Other benefit sharing agreements on water allocations (Pak, Wegerich, & Kazbekov, 2014; Soliev et al., 2015) or smaller transboundary infrastructure received little attention (Pak & Wegerich, 2014; Soliev, Theesfeld, Wegerich, & Platonov, 2017; Wegerich, Kazbekov, Mukhamedova, & Musayev, 2012).

Our research on various water management departments of the region on national, province and district levels, which continued for the last seven, eight years, pointed toward substantial costs these departments have to bear despite the well-known decline in economic return from water sector in the region. Particularly, this is the case for Uzbekistan. Cost intensive large pumping stations in the country that lift water to large-scale irrigation systems are well-documented. For example, Bucknall et al. (2003, Annexes 19) describe high costs that are induced by lifting water from the Amu Darya, the other major river in the region, to the provinces of Surkhandarya (66% of total irrigated area), Kashkadarya (80%) and Bukhara (100%). Khamraev (2011, p. 80) reports that about "70% of the Ministry of Agriculture and Water Resources (MAWR) budget is allocated to electricity used by pumping stations". While some of these irrigation schemes can be simply attributed to the hydraulic mission of the Soviet

Union, such as in Kashkadarya and Surkhandarya provinces (Saiko & Zonn, 2000), others can be assigned to the expansion of irrigated area in upstream territories within Uzbekistan, such as in Bukhara Province (Wegerich, 2014). However, little attention has been paid so far to the increase of pumping stations to cope with the expansion of irrigated areas in other riparian states (Pak et al., 2014; Wegerich, Soliev, & Akramova, 2016). The upstream irrigation expansion was part of a compensation mechanism under the broader benefit sharing arrangements on a basin level during the Soviet Union. The upstream irrigation expansion had their direct transboundary implications within smaller transboundary tributaries (STTs) and therefore on a different level. These local consequences and the interactions within transboundary benefit sharing across different—from basin to local—levels remain unexplored.

Here the focus is on Ferghana Province within the Ferghana Valley. Based on archival data analysis of agreements and correspondence on shared water development in the valley (from 1960s to 2013), annual reports of the Ferghana Province Water Management Department (WMD) (from 1978 to 2010), and interviews with key informants, we aim to illustrate and stress some of the long-term costs borne by the Ferghana Province WMD as a result of earlier and broader benefit sharing arrangements. We set the following three objectives: first, we establish the link between broader benefit sharing arrangements on the basin level and more localized irrigation expansion in Kyrgyzstan as a compensation mechanism; second, we analyze the connection between expansion of the irrigated area in upstream Kyrgyzstan and the increase of pumping stations in downstream Ferghana Province of Uzbekistan; and third, we disentangle and stress the costs of coping with upstream expansion for downstream Ferghana Province.

We continue with a theoretical overview outlining costs within the benefit sharing approach in the context of transboundary water governance. This is followed by a brief geographic description of Ferghana Province, its water resources and a historical background to the expansion of pumping stations in the Uzbek Soviet Socialistic Republic (SSR). Then we provide an empirical example with longitudinal analysis of benefit sharing arrangements affecting Ferghana Province, Uzbekistan. This section has three subsections: changing water allocations and upstream irrigation expansion; compensation mechanisms; and financial consequences for the Ferghana Province WMD. In the discussion section, we reflect on the identified costs and bring back the theoretical discussion on benefit sharing for analyzing the empirical evidence from various angles. Finally, we conclude by highlighting key findings stressing the need for considering the costs within the benefit sharing approach.

2. The benefit sharing approach: Costs

Since the early 2000s, the benefit sharing approach (Sadoff & Grey, 2002) gained increased prominence. Sadoff and Grey (2005, p. 3) define benefit sharing as "any action designed to change the allocation of costs and benefits associated with cooperation". Here the term "any action" seems to make the definition too broad and can be put into question. Tarlock and Wouters (2007) highlight that shared benefits often substitute more comprehensive basin solutions and that "mutually beneficial" does not necessarily mean equitable,

especially in the long term as circumstances might change. Overall, the concept is still under explored (Phillips, Daoudy, McCaffrey, Öjendal, & Turton, 2006). The literature highlights more benefits of potential cooperation along transboundary rivers, and costs of cooperation are not emphasized sufficiently. Sadoff and Grey (2002) for example, mainly addressed the costs from the perspective that utilizing benefit sharing will reduce costs. They state: "International cooperation can ease tension over shared waters, and provide gains in the form of the savings that can be achieved, or the costs of non-cooperation or dispute that can be averted" (Sadoff & Grey 2002, p. 398).

In a later publication, they (2005, p. 3) mention costs of cooperation: "The costs of cooperation could be directly associated with the institutional or physical costs of river development and management (for example, river regulation and storage costs), or any other costs that the negotiating parties choose to include for consideration (for example, hydropower interconnection and distribution costs)". A recent study by Soliev et al. (2015) systematized the costs associated with benefit sharing on a conceptual level by analyzing almost a century-long riparian relationship in the Ferghana Valley. They identify four general categories of costs (costs related to equity of sharing, costs to the environment, transaction costs and risks of losing water control, and costs resulting from misuse of issue linkages). Soliev et al. (2015, p. 2743) note: "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". Hence, there is a challenge in defining system boundaries that can be attributed to (i) complexity of arrangements on the one hand, and (ii) time horizon on the other.

We explore the system boundaries perspective (Laumann, Marsden, & Prensky, 1983) that could help bring differing views among scholars as to what qualifies as benefit sharing to a common denominator. The case in point is compensation. Sadoff and Grey (2005, p. 4) mention: "Payments for benefits (or compensation for costs) might be made in the context of a cooperative scheme". However, there is an argument to be made that if riparian state A benefits from new arrangements, and riparian state B receives only compensation for losses, then it is not benefit sharing. For example, Soliev and Theesfeld (2017), analyzing global trends in application of the benefit sharing approach in water, land and biodiversity resource domains, stress this point, and assert that for benefit sharing to be sustainable in the long run it should entail sharing of the surplus of benefits as a result of cooperation. Likewise, Tarlock and Wouters (2007) highlight that water treaties should be win-win situations. Compensation alone, where one wins and the other only maintains the status quo, could be interpreted as unfair treatment. Similarly, Hensengerth et al. (2012, p. 10) term agreements as benefit sharing agreements if "cooperation will produce net benefits and […] make all the various parties better off compared with the status quo or unilateral action". Consequently, they do not consider simple compensation as a benefit sharing agreement (such as on the Aswan High Dam between Egypt and Sudan). Hence, the contradiction here is whether compensation helps to make the various parties better off compared to the status quo.

Klaphake (2006, p. 110) explains the use of compensation as a mechanism of benefit sharing when benefits "do not accrue uniformly or symmetrically". Thus, depending on the identified system boundaries, compensations can be seen as both an unfair treatment and a

mechanism that makes benefit sharing equitable. Although Klaphake (2006) distinguishes between compensation (monetary and non-monetary) and issue linkages (within the water sector and outside the water sector), the difference seems to be symbolic. Issue linkage can be considered as a more complex form of compensation when one side or both sides compensate the other or each other in return for increased benefits on one issue by making concessions on another. Given that issue linkages by definition are agreed on shared issues (for example, mutual concessions on two shared rivers, barter agreements involving different sectors such as water and energy), it seems important to take into account costs and benefits of each individual compensation mechanism as it might have a second degree of effect on the balance of shared benefits. As Hensengerth et al. (2012, p. 9) put forward "ideally, all related costs (including capital, operating and maintenance, opportunity and external costs) and all related benefit streams (including direct and indirect use values, positive externalities and intrinsic values) are taken into account in the sharing of the benefits".

The second important aspect is the time horizon. On the one hand, whether an arrangement is a one-time transaction (for example, monetary compensation) or a recurring one (for example, periodic or continuous payments or sharing of the gains) might completely change the nature of benefit sharing. In this sense, issue linkages seem to be more equitable compared to monetary compensations as the sides can utilize the resources in ways they deem necessary with the possibility to adapt to changes over time. On the other hand, while for sustainability of benefit sharing arrangements it is important to estimate long-term costs, a number of factors might limit such exercise: at least, availability of information, and dynamics in perception as to what is considered beneficial. Since decision making regarding infrastructure projects is based on available information, as well as perceptions on existing problems and solutions, earlier solutions might be outlived and have to be updated over time. Tarlock and Wouters (2007), looking at older treaties in a number of examples across the globe, highlight that different aspects such as implications for ecosystems but also for indigenous communities were not considered in the past. It is likely that when taking a longer time horizon, circumstances and factors influencing the perception on benefits will change. Hence, what was perceived beneficial at one point might not be perceived as such in the long term (Hartmann, 2012). Therefore, this calls for a periodical reevaluation of any benefit sharing agreements. Similarly, the emphasis of Hensengerth et al. (2012) on operation and maintenance costs highlights the long-term perspective. Unforeseen or underestimated changes in costs can have significant implications, affecting the overall structure of desired benefit sharing.

3. Background to Ferghana Province

Ferghana Province is located in the Uzbek part of the Ferghana Valley (Figure 1). The province occupies 6,800 km^2, consists of fifteen districts and four major cities, and has a total population of about three million. The province borders Kyrgyzstan to the southeast, Tajikistan to the west, and two Uzbek provinces Andijan and Namangan to the east and north respectively. A closer look reveals a complex system of interdependent water resources utilized in the province. The main stem of the Syr Darya is formed from confluence

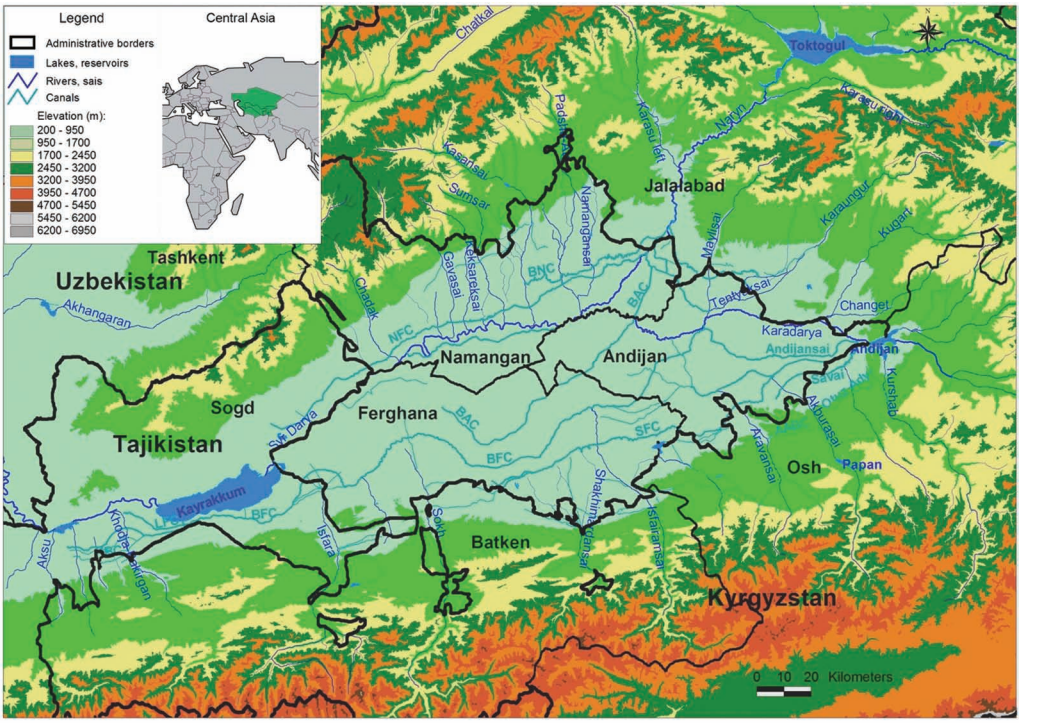

Figure 1. The Ferghana Valley: topography, water resources and infrastructure (Soliev et al., 2017)

of the Naryn and Karadarya both of which originate in Kyrgyzstan. The Big Ferghana Canal (BFC) diverts water from the Naryn and is controlled by the Toktogul Reservoir in upstream Kyrgyzstan. The Karadarya is controlled by the Andijan Reservoir, which is in turn, operated by Uzbekistan. The South Ferghana Canal (SFC) takes water directly from the Andijan Reservoir, and the Big Andijan Canal (BAC) diverts water from the Naryn. There are also four small transboundary tributaries (STTs) originating in Kyrgyzstan, and entering the province from the south: Isfayramsai, Shakhimardansai, Sokh and Isfara (from east to west), all of which intersect with the SFC and/or BFC (Soliev et al., 2015). On all main canals and small tributaries, Ferghana Province is at the tail end.

Up to the mid-1980s, the Uzbek SSR was engaged in the hydraulic mission, increasing the irrigated area to 4.2 million ha. Within Ferghana Province, the irrigated area increased to 368,300 ha by 1988. After independence, the irrigated area has stabilized at about 361,000 ha from 2006 onwards. The expansion of the irrigated area was driven by diverting water from the main stem and the larger tributary of the Syr Darya, but also by creating smaller storage reservoirs to capture winter flow and for more control along small tributaries. Given the location of Uzbekistan mainly within the Valley, smaller storage reservoirs were often constructed upstream in Kyrgyzstan or directly on the border between Uzbekistan and Kyrgyzstan. In many instances, a benefit sharing approach was considered, in which both

riparian states benefitted through an increase and joint utilization of water shares (Pak & Wegerich, 2014; Soliev et al., 2015).

Within Ferghana Province, according to Bucknall et al. (2005, p. 19) about one third of the irrigated area, 115,000 ha, is supplied via pumping stations (lift). Focusing on the economics of agriculture, Bucknall et al. do not look at the reason for the construction of pumping 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 pumping stations to compensate the loss of water supply to existing irrigated areas within their territories from other water sources (the Syr Darya and BFC) due to the expansion of irrigated area in the upstream Kyrgyz SSR in the 1970s. Hence, there is an indication that not all pumping stations were constructed because of the hydraulic mission within the former Uzbek SSR. At the same time, our data show that changes in irrigated area for the period from 1978 to 2010 were accompanied by disproportionate increases of lift irrigation for the same period (Figure 2). The data suggest that to some extent existing irrigated area shifted the water source, from direct diversion from a small river or canal to water supply via pumping stations either from a different canal or directly from the Syr Darya.

Wegerich (2014) suggests that the increase of pumping stations might be related to rising competition within a closing basin, both on the national and province levels. 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 mainly focusing on benefit sharing of water resources, pastures and shared reservoirs, they do not address compensation through pumping stations. Wegerich et al. (2016) explain the dynamics in costs related to lift irrigation but do not address the broader benefit sharing questions.

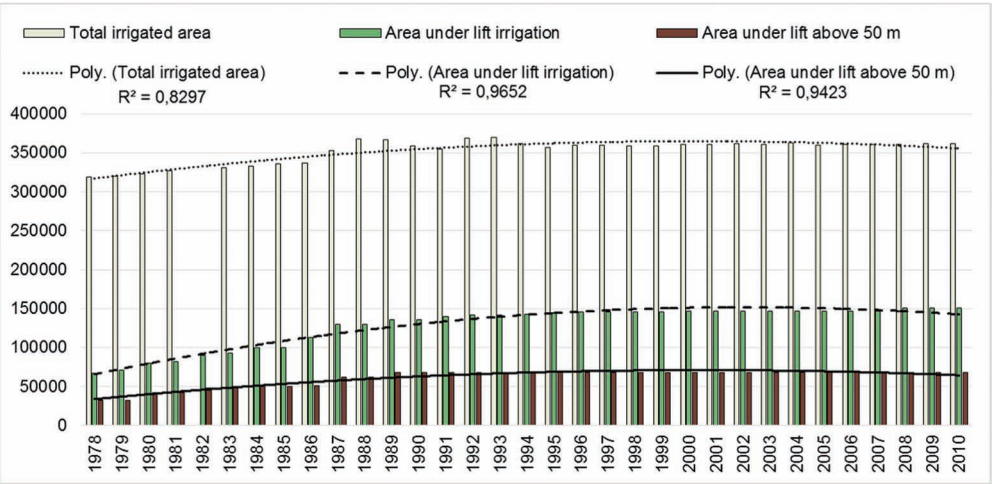

Figure 2. Irrigated area and increase of lift irrigation from 1978 to 2010, in hectare (No data available on total area for 1982)
Source: Figure developed by Ilkhom Soliev

4. An empirical example: Broader benefit sharing and localized costs for Ferghana Province

4.1. Broader projects with shared benefits and expansion in Kyrgyzstan, upstream to 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, as part of 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 on the issues of design and construction of the Sokh Reservoir," 1986; "Resolution of the SEC," 1973; "Resolution of the Central Committee," 1977). It should be noted that it was only one element in the broader arrangement with shared benefits, which also included construction and resettlement, funded by Moscow; direct compensatory funds received by the Kyrgyz SSR, who also was expected to have its share directly from the Toktogul; and several compensatory arrangements on other shared infrastructure. It was a so-called framework arrangement, details of which were to be developed directly within negotiations between the republics.

One of the plans was to expand the irrigated area within the Sokh Basin, the plan expected to benefit the Kyrgyz SSR significantly. The idea was to use the Sokh water by direct withdrawals through canals, as well as through construction of the Sokh Reservoir to store and regulate the flow. This way, the Burgandy Massif, an area with favorable soil for irrigated agriculture in the Sokh Basin shared by upstream Kyrgyzstan and downstream Ferghana Province, received a priority for irrigation infrastructure development. However, against the background of the much larger Toktogul project, it was still not the top priority, and works on the Sokh Reservoir did not start for a while. The next top project—the Andijan Reservoir on the Karadarya, the second largest tributary of the Syr Darya—was negotiated directly between the Uzbek and Kyrgyz SSRs in 1962-1965, and both parties reiterated the Sokh Reservoir during these negotiations with additional plans of building the Left-Shore Kampyr-Ravat (LSKR) Canal to deliver water to the Burgandy Massif. Now the focus started to shift from the Sokh Reservoir per se, to the overall expansion of the irrigated areas in the upstream Kyrgyz SSR. While the LSKR Canal was to irrigate 8,000 ha in the Kyrgyz part of the Burgandy Massif and 15,900 ha in the Uzbek part ("Protocol of the Meeting of the Representatives," 1965), the Kyrgyz SSR set forward a number of other areas for further expansion that had direct impact on the water available downstream (Table 1).

However, the downstream implications neither of the compensatory Burgandy Massif nor of the internal projects of the Kyrgyz SSR were taken into account. While the Andijan Reservoir was completed in 1978, the LSKR Canal was still not approved, and an internal document of the Osh Province WMD states "to take water from all the other rivers if the Uzbek SSR does not construct the LSKR Canal" ("Reference Certificate," 1974).

In 1980, new water sharing arrangements were agreed regarding the STTs in the Ferghana Valley, developed by the design institute Sredazgiprovodkhlopok ("Protocol of the Inter-Republican Meeting," 1980). However, the Kyrgyz SSR expressed its disagreement

Table 1
Extract from 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 Massif	6,000	6,000
Isfayramsai-Shakhimardansai STTs	6,500	6,500
Burgandy Massif	-	8,000
Total	21,500	29,500

Source: "Report of the Minister of Water resources" (1973)

over the shares, particularly, claiming that (1) the non-built LSKR Canal and (2) the feeding of the Isfayramsai and Shakhimardansai STTs from the SFC, and of the Sokh STT from the BFC were not taken into account. As a response, Sredazgiprovodkhlopok explained that 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 water 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).

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. Already at that time, the lion's share of the irrigated area was utilizing water from the Karadarya and STTs. The proposed additional increase led to further negotiations and clarifications on the lands and water allocation shares. To implement the "Protocol of the Inter-Republican Meeting" (1980), the Ferghana and Osh Province WMDs concluded an Agreement ("Agreement on Regulation of the Issues of Water Allocation," 1980), considering the construction of the Sokh Reservoir and LSKR Canal, as well as water allocation from the four STTs: Isfara, Sokh, Shakhimardansai and Isfayramsai. After the agreement, the construction works of the Sokh Reservoir on the Sokh STT were initiated ("Decision of the Executive Committee," 1980; "Protocol of the Meeting on Agreement," 1988). Despite the 1980 Protocol and the reallocation of shares, the Kyrgyz SSR continued to demand an increase on almost all STTs ("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 91 million m^3 as per "Protocol of the Inter-Republican Meeting" (1980) to 296.5 million m^3 ("Protocol No. 3 of the Technical Meeting," 1989).

After independence in 1991, the five Central Asian states signed the Almaty Agreement in 1992. They recognized the necessity for cooperation and agreed to honor the existing agreements. Nevertheless, due to the financial crisis after independence, the construction works on the Sokh Reservoir stopped and only the started resettlement works continued ("Letter from the first Deputy Prime Minister," 1993). In 1998, the Syr Darya Framework Agreement, which focused on the operation of the Toktogul Reservoir, was signed between Kazakhstan, Kyrgyzstan and Uzbekistan. In the 2000s and with the failure of 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 (Soliev et al., 2015). Even

though there was already an additional water shortage for Uzbekistan on the main stem of the river because of increased winter releases by Kyrgyzstan, in 2001 Kyrgyzstan and Uzbekistan came to an oral agreement to share three STTs (Sokh, Shakhimardansai and Isfayramsai) on 50/50 basis (Soliev et al., 2017). This agreement further significantly reduced the overall water share of Ferghana Province (Compare with Protocols from 1980 and 1989).

4.2. Consequences of upstream expansion for Ferghana Province

The Ferghana Province WMD was not prepared to cope with the upstream irrigation expansion. Correspondence from 1979 in Ferghana Province, addressed to the Osh Province WMD, the Uzbek SSR government and Moscow, shows that the Kyrgyz SSR rapidly increased water use from the Sokh STT diverting to the Burgandy Massif. At the same time, the Kyrgyz SSR unilaterally diverts the Isfara STT to the newly constructed Tortgul Reservoir. By this period, as the plans on most of the infrastructure targeting the Uzbek part of the valley had been agreed (Toktogul, Andijan, Kayrakkum reservoirs, a number of canals), it can be assumed that the Uzbek SSR was still in the expansion mode according to its past plans. Lifting water to rearrange water sources became one of the main strategies to adjust to the ongoing changes. Below we disentangle the growth in lift irrigation (in general and as transboundary compensation) from the growth in total irrigated area. In doing so, we also particularly highlight the pumping stations with lift height beyond 50 m; these were large infrastructure projects with significant effect on water use on the one hand, and significant cost implications on the other.

The expansion in the upstream Kyrgyz SSR had consequences for Ferghana Province at least in two ways. First, expansion upstream meant less water for existing irrigated areas downstream and Ferghana Province had to find alternative options to deliver water to the existing irrigated areas. We refer to this effect as direct transboundary compensation. This was primarily done by construction of pumping stations. The irrigated area of Ferghana Province rose from about 285,000 ha in 1969 to 320,000 ha in 1979 (+12% growth in a decade). While the total irrigated area under lift increased from about 16,000 ha (1,000 ha for uplift >50 m) to 71,000 ha (+343%) (33,000 ha for uplift >50 m), and the data provided by the Ferghana Province WMD show that four of these pumping stations (uplift >50 m) with the total capacity to irrigate over 11,000 ha were constructed with the purpose to compensate for transboundary upstream expansion (Table 2; Figure 3). Second, the WMD also highlighted that between 1969 to 1979 seven pumping stations (uplift >50 m) were constructed to moderate the effect from construction of the above four pumping stations since they took water from the sources that had been already in use (Table 3). We refer to this second degree of effect as internal intensification. All of the pumping stations constructed for internal intensification were in the eastern part of Ferghana Province and within the tail-end area of the Isfayramsai and Shakhimardansai STTs and SFC.

In the period from 1980 to 1989, the irrigated area in Ferghana Province increased to 367,000 ha (+15% in a decade), and the area under lift irrigation increased to 136,000 ha (+91%) (68,000 ha for uplift >50 m). All pumping stations classified as transboundary compensation, which were constructed during this period, were within the basins of the

Table 2
Direct transboundary compensation for upstream expansion through pumping stations (due to the complexities in the border regions the list might not be exhaustive, and should be treated with caution)

#	Pumping station name	Year of construction	Location, district	Power (kWh)	Max capacity ($м^3$/sec)	Lift height (meters)	Irrigation area (ha)	Source of water	No. of staff
1	Isfayram-Shakhimardan	1972	Quvasoy			50	3600	SFC	11
		1974		12500	4.8	180	5000	SFC	
2	KFK-SSHK-1	1974	Oltiariq	3200	3.2	50	2850	BFC	9
3	KFK-Sokh	1975	Uzbekistan	9100	4.4	170	3640	BFC	11
4	KFK-Rishton-1	1979	Rishton	750	0.9	66	460	BFC	5
5	Bogdod	1980	Bogdod	5670	2.25	160	1430	BFC	11
6	Chuvrindi-2	1980	Bogdod	500	0.6	67	500	BFC	5
7	Rapkon-1	1980	Beshariq	2520	1	200	800	BFC	11
		1980		630	0.4	200		BFC	
		1980		3150	1	200		BFC	
8	Ganiobod-1	1980	Uzbekistan	1890	1.2	85	700	BFC	8
9	Nursuh	1984	Uzbekistan	4450	3.3	90	800	BFC	9
10	Bogdod-Rishton-2	1987	Bogdod	1600	4.2	90	2500	1 level	6
		1987		2400		90	2500	1 level	
11	Buloqboshi-1	1989	Rishton	3780	3.6	125	4480	BFC	12
				4000	2	80			
	Total			56140	32.85	1903	29260		98

Source: Authors' own compilation based on the analysis

Sokh STT and Isfara STT. All pumping stations classified as internal intensification were constructed within the Sokh Basin, with the exception of the one in Toshloq district.

In the period from 1990 to 1999, the total irrigated area dropped to 358,000 ha (–3% in a decade) while the irrigated area under pumping stations increased to 146,000 ha (+7%) (69,000 ha for uplift >50 m). There was no pumping station constructed with uplift beyond 50 meters to compensate transboundary expansion during the 1990s. However, during this period three pumping stations were constructed that were mentioned under internal intensification. The WMD confirmed (as of 27 January 2014) that more water from the Isfayramsai STT was utilized after independence. Given the overall water insecurity after independence, one could also classify these pumping stations as a consequence of transboundary insecurity, but this time based on the overall insecurity along the main canals dependent on the operation of the Toktogul Reservoir.

Despite the changes, in the period from 2000 to 2009 the irrigated area in Ferghana Province increased again to 362,000 ha (+1%) and the irrigated area via pumping stations increased to 151,000 ha (+3%) (69,000 ha for uplift >50 m). There was no pumping station constructed with uplift beyond 50 meters classified to compensate transboundary expansion or as internal intensification during the 2000s.

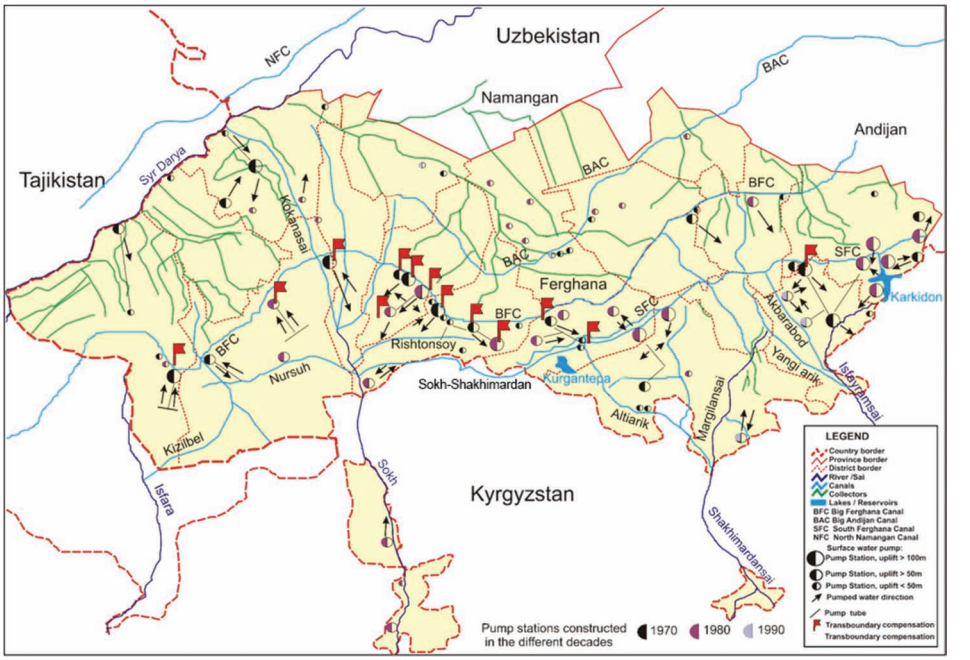

Figure 3. Pumping stations in Ferghana Province, highlighting the ones constructed to cope with upstream irrigation expansion (flagged)
Source: Map developed by Indira Akramova and Nozilakhon Mukhamedova

4.3. Disentangling the costs of coping with upstream expansion for the water management department

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 pumping stations. While with larger infrastructure, such as dams, these costs could be more easily determined (Hutchens, 1999), pumping stations are absorbed within the wider budgets of the Ferghana Province WMD, and there is no distinction between pumping stations that were constructed for compensation of loss due to upstream expansion and internal intensification 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 energy), as well as maintenance and rehabilitation expenditure. To disentangle the costs of pumping stations constructed due to transboundary expansion and internal intensification from the total costs, a categorization for estimating these costs was established[1]. The estimation was consequently applied for all relevant costs of pumping stations.

Overall, as we have seen in the previous section, there was a disproportionately significant increase in the number of pumping stations over the years compared to the increase in the

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

Table 3
Pumping stations constructed to compensate for internal intensification (due to the complexities in the border regions the list might not be exhaustive, and should be treated with caution)

#	Pumping station name	Year of construction	Location, district	Power (kWh)	Max capacity ($м^3$/sec)	Lift height (meters)	Irrigation area (ha)	Source of water	No. of staff
1	Oq tom	1970	Ferghana	500	0.6	55	280	Collector	7
2	Yangi bog	1970	Ferghana	110	0.5	50	320	BFC	6
3	Buston	1970	Quva	750	0.75	72	156	SFC	7
4	Loyson	1970	Qushtepa	900	1.6	68	750	Collector	7
		1972				50	3600	SFC	
5	Hangiz-1	1971	Ferghana	500	0.6	50	280	Collector	7
6	Hangiz-2	1971	Ferghana	750	0.9	55	250	Collector	7
7	Pahta uchun	1976	Quvasoy	2520	1	156	750	Sai	9
8	KFK-Rishton-2	1983	Rishton	320	0.7	280	214	Dutir	5
9	Oltiariq-2	1983	Oltiariq	300	0.5	50	250	BAC	5
10	Navbahor	1986	Toshloq	1000	2.4	62	1150	BFC	7
11	Lola	1989	Oltiariq	1260	1.2	55	900	BFC	7
				110	1				
12	Sharq yulduzi	1990	Quvasoy	119	0.7	80	70	Isfayram	5
13	Karamkul	1994	Quvasoy	500	0.5	70	320	Isfayram	7
14	Kaptarhona	1994	Ferghana	500	0.6	70	230	Logon	6
	Total			10139	9.05	1223	9520		92

Source: Authors' own compilation based on the analysis

total irrigated area. Looking at the staff requirements reported by the Ferghana Province WMD for the pumping stations, as was also confirmed by key informants, increases in pumping stations meant more staff for operation (day-to-day running of the pumping stations), maintenance (e.g., changing parts and oil) and rehabilitation (e.g., repairing out-of-order units that required modernization). The increases in staff in the Ferghana Province WMD in the 1980s thus can be mainly attributed to the increase of pumping stations (Table 4). In the period from 1980 to 1990, the irrigated area rose from 320,000 to 367,000 ha (an increase of 47,000 ha; +14.7%) while the total staff of the irrigation department rose from 3,083 to 3,813 (an increase of 730 staff; +23.7%).

There has been a significant increase of pumping stations during the 1970s. The total irrigated area under pumping stations increased from 16,000 to 71,000 ha, with total lift beyond 50 m from 1,000 to 33,000 ha. The official requirement for the pumping stations with total lift beyond 50 m alone was 153 staff, from these 41 and 50 staff were required for pumping stations classified as transboundary compensation and internal intensification respectively or a total of +60% of increase in staff. The official requirement for pumping stations with lift above 50 meters constructed during the 1980s was

Table 4

Changes in number of staff

Year	All staff	Administrative and managerial staff	Engineers and technicians	Others	Increase in staff at pumping stations (uplift >50 m)	Increase in staff on transboundary pumping stations (uplift >50 m)	Increase in staff on internal intensification pumping stations (uplift >50 m)
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			

Source: Authors' own compilation based on the analysis

200 staff. Of these 200 staff, 67 and 28 staff were for pumping stations classified for transboundary compensation and for internal intensification respectively or, in total, a 47.5% of increase in staff.

The Ferghana Province WMD provides data for operational as well as maintenance and rehabilitation (M&R) costs of pumping stations. As mentioned, since the reports make no distinction on whether the pumping stations were built to cope with expansion of irrigated area upstream, there is likewise no distinction in reporting the costs due to expansion of irrigated area in Kyrgyzstan. We discerned these costs through information provided by key informants and by verifying that information with the locations of pumping stations, their connection to transboundary water sources or to pumping stations directly connected to transboundary water sources (as reported in Tables 2 and 3, and partly visualized in Figure 3). We provide the results in Figure 4. First, already during the Soviet

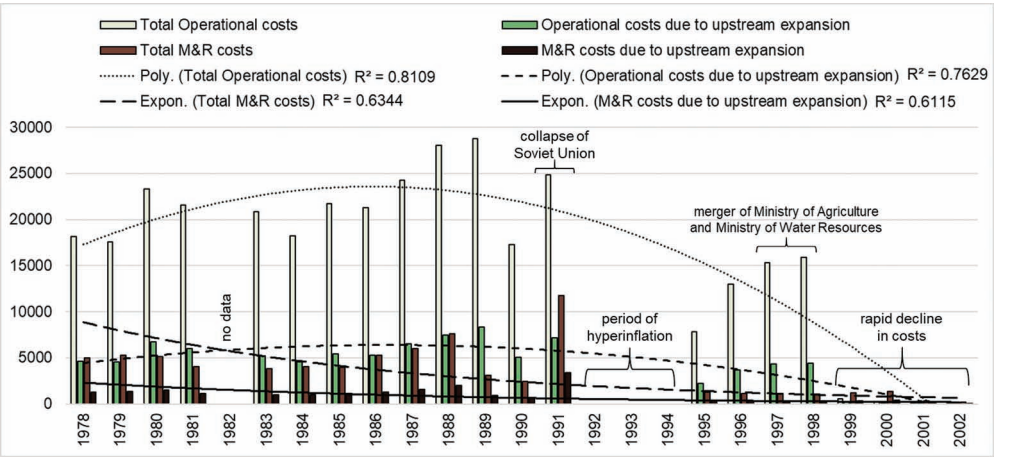

Figure 4. Operational and M&R expenditures at the Ferghana Province WMD related to pumping stations from 1978 to 2002, in thousand USD with buying power for 2014.
Source: Figure developed by Ilkhom Soliev

period, the operational and M&R costs of pumping stations increased continuously, and by far outstripped the maintenance costs of simple canal irrigation, which were mainly for de-silting. After independence in 1991, Uzbekistan continued with the Soviet Ruble, and after experiencing hyperinflation in 1993, shifted to an experimental Uzbek currency (sum coupon) and finally to Uzbek sum (UZS) in 1994 (Pomfret, 2006). We exclude this period from comparison across the years. During this period, the salary of WMD staff reduced extremely. Only from 1996 onwards, the GDP increased again (Taube & Zettelmeyer, 1998). Overall, in the analyzed period, about one third of the total costs accounted for the pumping stations constructed to compensate for transboundary expansion and internal intensification. After the merger between the Ministry of Agriculture and the Ministry of Water Resources in 1997 (Wegerich, 2005), expenditure saw a rapid decline in operational and M&R costs for pumping stations at the Ferghana Province WMD, reasons for which remain unclear at this point of analysis.

In addition, the WMD annual reports show that, with the exception of slight decreases every other year, the overall trend of operational costs was relatively stable until massive economic crisis in 1990. The slight decreases every second year between 1978 and 1986 can be primarily attributed to inflation rates of Soviet Union Rubles, as the actual costs in Soviet Union Rubles (Wegerich et al., 2016) show that only in 1984 and 1988 were there reductions in costs for total staff salary. This appears to have also affected the staffing at pumping stations, and therefore is noticeable in salary costs (Figure 5). Directly after independence and up to 1995, the WMD's total work force increased; however, the total salary was much below the pre-independence levels. When it comes to costs of energy, the trend is mainly at increase over the years until 1990, too. In 1997, at the time of the merger of the Ministries, and by 1998 the energy costs of pumping stations were comparable to the pre-independence levels reaching about USD 117 per hectare. However, after the merger,

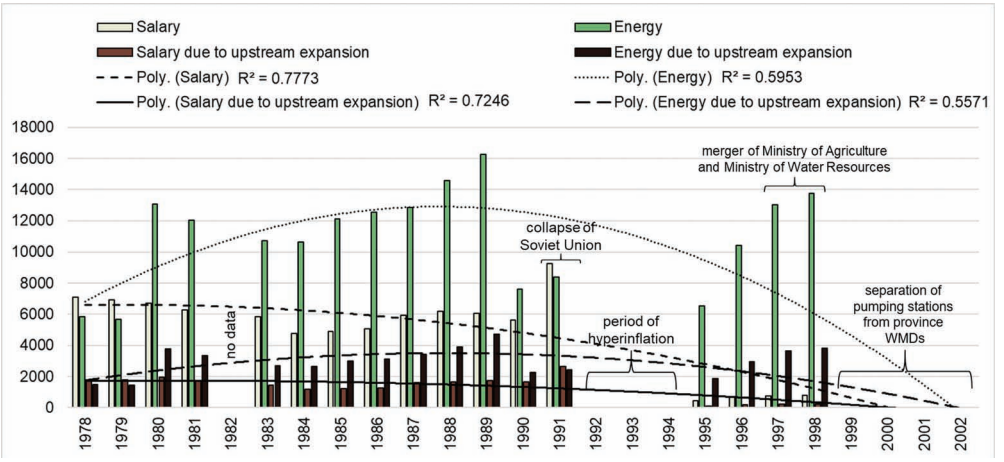

Figure 5. Salary and energy costs of pumping stations at the Ferghana Province WMD from 1978 to 2002, in thousand USD with buying power for 2014.
Source: Figure developed by Ilkhom Soliev

we have found that the pumping stations were handed over to a separate organization—Department of Pumping Stations and Energy—with a direct subordination to the national level Ministry of Agriculture and Water Resources. Therefore, the total operational budget of the pumping stations disappears from the expenditure reports of the Ferghana Province WMD (Figure 5), which explains the rapid decline in operational costs after 1998 (Figure 4). Although this seems to have eased the burden on the Ferghana Province WMD, it shows a further, rather artificial, institutional separation of pumping stations, that is, delinking of compensatory issue linkages from the original arrangements. From a system boundaries perspective, this creates a false impression of reduced costs at the Ferghana Province WMD. Moreover, at the time this article was in press, the government of Uzbekistan announced reforming the Ministry of Agriculture and Water Resources back into the two separate Ministries— the Ministry of Agriculture and the Ministry of Water Resources respectively, implications of which are yet to be seen (Decree of the President of Uzbekistan, 2018).

5. Discussion

The empirical study demonstrated a clear example of how complex arrangements with shared benefits led to underestimation of significant costs resulting from these cooperative developments. Our attempt to define system boundaries specifically from two identified perspectives: (1) looking at benefit sharing arrangements and their effect as a system taking into account all possible individual elements, and (2) over a long time horizon—showed gradual increase of costs of lift irrigation in coping with upstream expansion to unsustainable levels. Interestingly, although the lift irrigation was a significant mechanism in achieving broader arrangements with shared benefits, including in the construction of the Toktogul, the pumping stations constructed to compensate losses because of continuous water shifts were never clearly linked to these broader arrangements in negotiations nor were they seen as a separate category in expenditure reports.

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. This might be particularly the case, since traditionally, population in this area are rather settlers than nomads, in contrast to those in Kyrgyzstan. Resettlements could have been regarded to be more costly, than the assumed costs of constructing lift irrigation. 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 while increasing benefits. Even in the best-case scenario of productivity (Bucknall et al., 2005; Keith & McKinney, 1997; Khamraev, 2011), the net irrigation benefits would be only marginal compared to the operational and M&R costs of pumping stations, particularly of those with lift height above 50 meters. Hence, the pumping 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 term.

Taking into consideration the operational and M&R costs of the pumping stations, the presented data show that the potential water stability for the Uzbek SSR came at a very high and uneconomic cost. According to Dukhovny and De Schutter (2011) during the period from 1980 to 1985 "more than 70 rubles [SUR] (USD 45 in 1980, which converts to USD 137 with buying power of 2014) per irrigated hectare were annually allocated to water management organizations". Only the average costs (operational and M&R costs) of pumping stations per irrigated hectare in Ferghana Province amounted to SUR 79 in 1980 (without construction costs). The expansion of the irrigated area under lift to compensate for upstream expansion was therefore a clear burden for the allocated average budget per hectare. However, at the time when the pumping stations started to be constructed, the large scale hydropower station in the Kyrgyz SSR (Toktogul) was already anticipated; therefore, it is possible that regarding operational costs (energy) an issue linkage approach connecting water and energy sectors was expected. However, none of the studied documents for shifting water rights between the Kyrgyz and the Uzbek SSR support that such issue linkage was considered in the negotiations. Previous research of the co-authors highlight that ownership of transboundary water infrastructure and therefore the responsibility for operational and M&R costs, as well as other compensation mechanisms (land and resettlement), were clearly determined in negotiations (Pak & Wegerich, 2014; Soliev et al., 2015; Wegerich et al., 2012). In this respect, it appears that the pumping stations, constructed to compensate for upstream transboundary irrigated area expansion, were not considered in the same manner as other transboundary infrastructure and remained "invisible" within the republican budget.

The shift in operation of the Toktogul Reservoir after independence increased the instability of water supply at the level of main canals, and therefore also for the pumping stations. Thus, what had been considered from a short-term perspective as equitable compensation turned into an inequitable one in the long term. Looking at the 50/50 water sharing agreement on some STTs in 2001, it is evident that water sharing on the larger Naryn and the operation of the Toktogul (1998) had already failed. This agreement simply rendered water rights from Uzbekistan to Kyrgyzstan, without any potential benefits for Uzbekistan. Now, it seems Uzbekistan is paying double the price: losing the reliable source of water from the main stem of the Syr Darya because of the Toktogul's new energy mode of operation, but also from the STTs due to already expanded irrigated areas in Kyrgyzstan.

Further, from the temporal perspective, the expansion of the irrigated area upstream, particularly in the Sokh STT, in combination with the agreed Sokh Reservoir and the agreed (by Uzbek and Kyrgyz SSRs), but not approved by Moscow, LSKR Canal, was part of the compensation package for the construction of the Toktogul Reservoir. Therefore, the pumping stations within the Sokh STT could be interpreted as a consequence/compensation of an agreed another compensation package. They were the Uzbek compensation in STTs for more water control through the Toktogul in Kyrgyzstan benefitting Uzbekistan and loss of agricultural lands for Kyrgyzstan. Despite the fact that both areas are within the same basin and that through technical solutions water transfers from one tributary to the other are

possible, there appears to have been a clear lack of consideration of what is technically possible and what is economically feasible. This is in line with many other water infrastructure decisions at the time, such as those related to the Surkhandarya, Kashkadarya, and Bukhara pumping stations along the Amu Darya River (Dukhovny & De Schutter, 2011). Therefore, other aspects, such as increasing cotton production (Weinthal, 2002) and population pressure (Dukhovny & De Schutter, 2011), particularly in the Ferghana Valley which is densely populated, must have had priority over cost effectiveness. However, already in the beginning of the 1980s economic concerns of cotton production were voiced (Anderson, 1997).

Given that the expansion of the irrigated area in upstream Kyrgyzstan is partly due to compensation mechanisms of the Toktogul Reservoir, the current international focus on the operation of the Toktogul in isolation from past compensation mechanisms is problematic. The current benefit sharing approach is focused mainly on organizing an annual energy swap (hydropower versus fossil fuels) with water releases seen as a by-product. However, past compensations (such as expansion of irrigated area upstream and water reallocation along small transboundary tributaries) are not taken into consideration.

It would be desirable to explore further ways to quantify the costs and benefits integrating the rich knowledge available on the level of provinces. One way to do so, if for example a game theoretic approach is applied (Teasley & 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 presented here, a first step in such reframing would be to reconsider the water use schematic of the Syr Darya Basin, which is often simplified elsewhere. An example of moving from so-called reductionist to more integrative approach (Zeitoun et al., 2016) is illustrated in Figure 6. In such a setting, the obvious differences are that the number of players grows from 3 to 7 already within the Ferghana Valley (without considering the rest of the Syr Darya or greater Aral Sea Basin) and that the flow of the water resources is not unidirectional. 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. Naturally, that could be further analyzed by attaching corresponding weights to each of the water bodies based on their water balance, regulatory infrastructure, and water use characteristics (e.g., irrigated area, water demand). What would be the implications of a change in the Toktogul's operation for each of the players? How many more agreements would require a review and amendment if parties reach a new agreement with isolated focus on the Toktogul and Kayrakkum reservoirs?

Contemplating further broadly, the study and the ongoing discussion in the literature point toward the importance of addressing the fine balance between the need for action and the costs of action. We must acknowledge that in most of the regions of the world with transboundary water resources, the dialogue is needed more about benefits than costs of cooperation. Especially, in the developing countries, where riparian states are interested in cutting the expenses, conversations focused on costs are unlikely to encourage cooperation. It is understandable that scholars suggest that benefits of cooperation need to be demonstrated to be constructive in negotiations and bring about change. This is, however, a dangerous

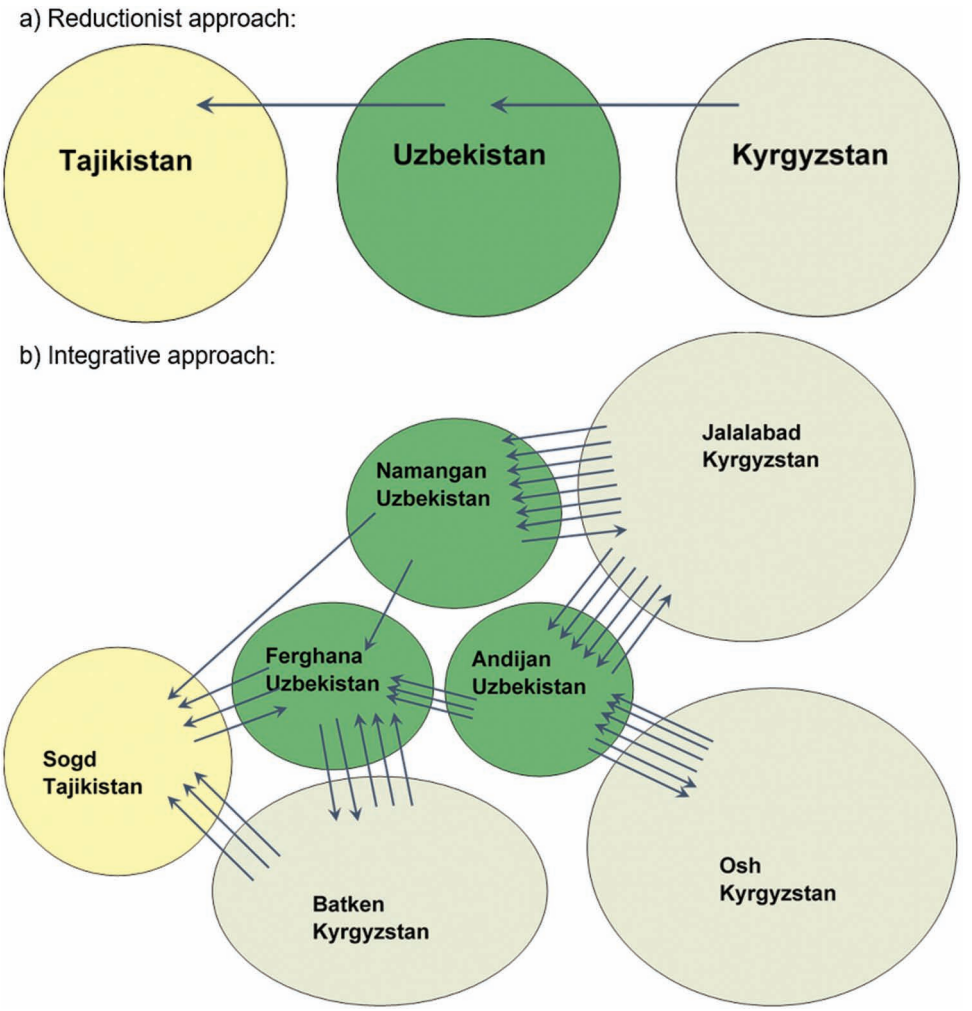

Figure 6. Reductionist (a) and integrative (b) approaches in research to benefit sharing in complex transboundary settings in the example of the Ferghana Valley (oval figures represent water users and arrows denote rivers and their flow direction)
Source: Illustration developed by Ilkhom Soliev

path that can lead to thinking that cooperation is without costs or that benefits will always outweigh costs. Similar to how Zeitoun and Mirumachi (2008) asserted that interaction in the context of transboundary water governance can be, and most of the time, is both co-operative and conflictive, we stress that within complex benefit sharing arrangements, it is important to consider adequately both the benefits and costs of cooperation by addressing at least the system and time perspectives as discussed in this paper. Based on our findings, we conclude our discussion by hypothesizing on basic configurations of considering costs and benefits of cooperative arrangements and four likely outcomes as provided in the below matrix (Figure 7).

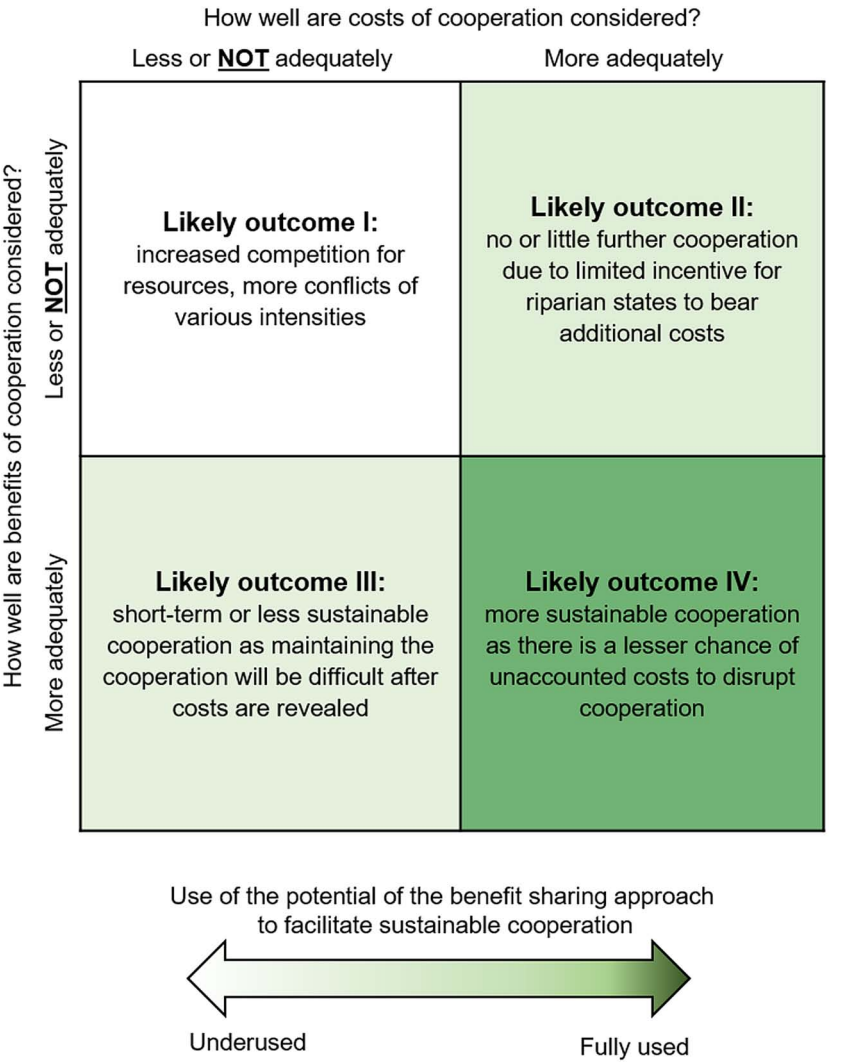

Figure 7. Matrix of balance in discussion of benefit sharing in transboundary water governance: configurations for considering costs and benefits, and four likely outcomes (likely outcomes are placed on a continuum to further stress the importance of adequate consideration of costs and benefits to fully use the potential of the benefit sharing approach to facilitate sustainable cooperation)
Source: Matrix developed by Ilkhom Soliev

6. Conclusions

While the benefit sharing approach emphasizes win-win solutions and even questions whether compensation should be considered as part of benefit sharing, this paper has highlighted how complex compensatory arrangements with shared benefits can lead to underestimation of significant costs. We have seen in our empirical example that while at the time the compensatory reallocations were perceived as technically feasible, with the focus

on bigger projects, long-term costs of separate elements of these bigger projects were not considered, and past incentives such as increasing cotton production and rising population pressure took priority. Hence, the case study highlights that valuing costs and benefits is strongly influenced by political rather than simple economic decisions. Therefore, what might be perceived as benefits at one point of time might not be perceived as such later. This highlights that perceived benefits are not written in stone, and therefore benefit sharing agreement should be seen as temporary, and thus revisable. To achieve more sustainable cooperation, both costs and benefits of cooperative developments need to be considered adequately, by addressing at least both system complexity and time horizon perspectives.

Within the Syr Darya Basin the current focus of benefit sharing is on large upstream dams alone (such as the Toktogul and Kayrakkum). 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 irrigation expansion by the late developer Kyrgyzstan should be considered as well. Including pumping stations in the proposed benefit sharing approach could entail free generated electricity for compensatory pumping stations.

Currently, the costs of compensation for the transboundary projects are partly borne by the water management department of Ferghana Province and partly by the newly created Department of Pumping Stations and Energy. Considering that these are transboundary compensation costs, they should be clearly separated and highlighted in the budgets as transboundary costs. On the one hand, bringing in costs into broader benefit sharing would allow more rational decision making. On the other hand, in light of other promoted approaches such as nexus that require higher integration across all levels and sectors, disentangling costs would allow avoiding the additional danger of ignoring the existing interconnected arrangements and transferring the costs associated with it to the end users.

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Editor's note

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References

Abbink, K., Moller, L. C., & O'Hara, S. (2009). Sources of mistrust: An experimental case study of a central Asian water conflict. *Environmental and Resource Economics, 45*, 283–318.

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 (1980) (in Russian).

Anderson, J. (1997). *The international politics of Central Asia*. Manchester, UK: Manchester University Press.

Antipova, E., Zyryanov, A., McKinney, D., & Savitsky, A. (2002). Optimization of Syr Darya water and energy uses. *Water International, 27,* 504–516.

Bekchanov, M., Bhaduri, A., & Ringler, C. (2015). Potential gains from water rights trading in the Aral Sea Basin. *Agricultural Water Management, 152,* 41–56.

Bucknall, J., Klytchnikova, I., Lampietti, J., Lundell, M., Scatasta, M., & Thurman, M. (2003). *Irrigation in Central Asia: Social, economic and environmental considerations*. Prepared for the World Bank. Retrieved October 20, 2014, from http://siteresources.worldbank.org/ECAEXT/Resources/publications/Irrigation-in-Central-Asia/Irrigation_in_Central_Asia-Full_Document-English.pdf

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. (1984, February 29). Sredazgiprovodkhlopok (in Russian).

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 No.440 dd. (1980, August 28) (in Russian).

Decree of the President of Uzbekistan. (2018). On the changes in the management system of agricultural and water resources sector. No. 5330 dd. (2018, February 12) (in Russian). Retrieved February 16, 2018, from http://agro.uz/ru/news/agro/ob-izmeneniyakh-v-sisteme-upravleniya-selskogo-i-vodnogo-khozyaystva-respubliki-uzbekistan

Dinar, A., Dinar, S., McCaffrey, S., & McKinney, D. (2007). *Bridges over water: Understanding transboundary water conflict, negotiation and cooperation*. Hackensack, NJ: World Scientific.

Dombrowsky, I. (2007). *Conflict, cooperation and institutions in international water management: An economic analysis.* Advances in Ecological Economics Series. Cheltenham, England: E. Elgar.

Dukhovny, V. A., & De Schutter, J. L. G. (2011). *Water in Central Asia: Past, present, future*. Leiden: CRC Press/Balkema.

Frenken, K. (2013). *Irrigation in Central Asia in figures: AQUASTAT survey—2012*. FAO Water Reports. Rome: Food and Agriculture Organization of the United Nations.

Granit, J., Jägerskog, A., Löfgren, R., Bullock, A., de Gooijer, G., Pettigrew, S., & Lindström, A. (2010). *Regional water intelligence report Central Asia*. Stockholm: Stockholm International Water Institute.

Hartmann, T. (2012). Wicked problems and clumsy solutions: Planning as expectation management. *Planning Theory, 11*(3), 242–256.

Hensengerth, O., Dombrowsky, I., & Scheumann, W. (2012). *Benefit-sharing in dam projects on shared rivers*. Bonn, Germany: German Development Institute.

Hutchens, A. O. (1999). *Example allocations of operating and maintenance costs of interstate water control facilities employing the use-of-facilities method* [online]. Prepared for Central Asia Mission, US Agency for International Development. Retrieved February 25, 2008, from http://www.adb.org/Documents/Reports/CAREC/Water-Energy-Nexus/appendix-A-19.pdf

Keith, J., & McKinney, D. C. (1997). *Options analysis of the operation of the Toktogul reservoir, environmental policy and technology (EPT)*. Issue Paper No. 7. Almaty, Kazakhstan: U.S. Agency for International Development.

Khamraev, S. R. (2011). The role of land reclamation in the socio-economic progress in Uzbekistan and government support policies of water management. In C. Madramootoo & V. Dukhovny (Eds.), *Water and food security in Central Asia*. NATO Science for Peace and Security Series C: Environmental Security (pp. 77–83). Dordrecht, The Netherlands: Springer.

Klaphake, A. (2006). Cooperation on international rivers from an economic perspective: the concept of benefit sharing. In W. Scheumann and S. Neubert (Eds.), *Transboundary water management in Africa—Challenges for development cooperation*, Studies No. 21 (pp. 103–172). Bonn, Germany: German Development Institute.

Laumann, E. O., Marsden, P. V, & Prensky, D. (1983). The boundary specification problem in network analysis. In R. S. Burt & M. J. Minor (Eds.), *Applied network analysis* (pp. 18–34). London: Sage.

Letter from the first Deputy Prime Minister of Uzbekistan to the Prime Minister of Kyrgyzstan on resuming works related to the Sokh Reservoir No. 30-5610 dd. (1993, June 25). Osh Province WMD (in Russian).

Memorandum on the issues of design and construction of the Sokh Reservoir. (1986). Prepared by the Chief Engineer of the project G.D. Sorokin. Ferghana Province WMD (in Russian).

Micklin, P. (2007). The Aral Sea disaster. *Annual Review of Earth and Planetary Sciences, 35,* 47–72.

Note to Protocol April 10, 1980 of the Ministry of Water resources of the Kyrgyz SSR, Osh Province WMD (in Russian).

Response Certificate from the design institute Sredazgiprovodkhlopok to the Note to the Protocol April 10, 1980 of the Ministry of Water Resources of the Kyrgyz SSR. Osh Province WMD (in Russian).

PA Consulting. (2002). *Transboundary water and related energy cooperation for the Aral Sea basin region of Central Asia. Phase I: Assessment of issues and proposals for Phase II*. Almaty, Kazakhstan: U.S. Agency for International Development.

Pak, M., & Wegerich, K. (2014). Competition and benefit sharing in the Ferghana Valley: Soviet negotiations on transboundary small reservoir construction. *Central Asian Affairs, 1*(2), 225–246.

Pak, M., Wegerich, K., & Kazbekov, J. (2014). Re-examining conflict and cooperation in Central Asia: A case study from the Isfara River, Ferghana Valley. *International Journal of Water Resources Development, 30*(2), 230–245.

Phillips, D., Daoudy, M., McCaffrey, S., Öjendal, J., & Turton, A. (2006). *Transboundary water cooperation as a tool for Conflict Prevention and Broader Benefit Sharing.* Global Development Studies. Stockholm, Sweden: Ministry of Foreign Affairs of Sweden.

Pohl, B., Kramer, A., Hull, W., Blumstein, S., Abdullaev, I., Kazbekov, J., … Görlitz, S. (2017). *Rethinking water in Central Asia: The costs of inaction and benefits of water cooperation*. Report by Adelphi and CAREC funded by Swiss Agency for Development and Cooperation.

Pomfret, R. (2006). *The Central Asian economies since independence*. Princeton, NJ: Princeton University Press.

Protocol of the Meeting of the representatives of the Ministry of Water Resources of the Uzbek SSR and Ministry of Water Resources of the Kyrgyz SSR, Design institutes "Sredazgiprovodhlopok" and "Kyrgyzgiprovodhoz" on use of water resources of the Kara-Darya River on the base of the Andijan/Kampyr-Ravat Reservoir held in Frunze on the 23rd of September 1965. Osh Province WMD (in Russian).

Protocol of the inter-republican meeting on the inter-republican water allocation in the small rivers of the Ferghana Valley, dd. (1980, April 10). Sogd Province WMD (water allocations were not approved) (in Russian).

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 of flooding by the Sokh Reservoir in the territory of the Kyrgyz SSR, Osh Province WMD, Kyrgyzstan, dd. (1988, February 12) (in Russian).

Protocol No. 3 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 held in Tashkent, Osh Province WMD, Kyrgyzstan, dd. (1989, August 22) (in Russian).

Raskin, P., Hansen, E., Zhu, Z., & Stavisky, D. (1992). Simulation of water supply and demand in the Aral Sea region. *Water International, 17,* 55–67.

Reference Certificate on Inter-republican water allocation issues between the Kyrgyz SSR and Uzbek SSR as of 1974. Osh Province WMD (in Russian).

Reference Certificate on the implementation of the Protocol 10 April 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, Osh Province WMD, Kyrgyzstan, dd. (1981, June 1) (in Russian).

Report of the Minister of Water resources of the Kyrgyz SSR to the Government of the Kyrgyz SSR on the Resolution No. 2 (1973, February 7) of the SEC Gosplan USSR as of 1973. Osh Province WMD (in Russian).

Resolution of the SEC of Gosplan USSR on expertise of the Scheme of the complex use of the water resources of the Syr Darya River No.2 dd. (1973, February 7). Osh Province WMD (in Russian).

Resolution of the Central Committee of the Communistic Party and the Council of Ministers of the Kyrgyz SSR "On the use of additional capital allocated as a compensation for the lands flooded by the Toktogul Reservoir in Osh province" No. 17 dd. (1977, January 9). Osh Province WMD (in Russian).

Sadoff, C. W., & Grey, D. (2002). Beyond the river: The benefits of cooperation on international rivers. *Water Policy, 4,* 389–403.

Sadoff, C. W., & Grey, D. (2005). Cooperation on international rivers: A continuum for securing and sharing benefits. *Water International*, *30,* 420–427.

Saiko, T. A., & Zonn, I. S. (2000). Irrigation expansion and dynamics of desertification in the Circum-Aral region of Central Asia. *Applied Geography, 20*(4), 349–367.

Sharma, R., Markandya, A., Ahmad, M., Iskakov, M., & Krishnaswamy, V. (2004a). *Water energy nexus in Central Asia. Improving regional cooperation in the Syr Darya Basin*. Washington DC: The World Bank.

Sharma, R., Markandya, A., Sachdeva, A., Iskakov, M., Krishnaswamy, V., Nikolov, N., & Pedroso, S. (2004b). *Central Asia regional electricity export potential study*. Washington DC: The World Bank.

Soliev, I., Wegerich, K., & Kazbekov, J. (2015). The costs of benefit sharing: Historical and institutional analysis of shared water development in the Ferghana Valley, the Syr Darya Basin. *Water, 7*(6), 2728–2752.

Soliev, I., Theesfeld, I., Wegerich, K., & Platonov, A. (2017). Dealing with "baggage" in riparian relationship on water allocation: A longitudinal comparative study from the Ferghana Valley. *Ecological Economics, 142*, 148–162.

Soliev, I., & Theesfeld, I. (2017). Reframing for sustainability: Exploring transformative power of benefit sharing. *Sustainability, 9*(8), 1486.

Stucki, V., & Sojamo, S. (2012). Nouns and numbers of the water-energy-security nexus in central Asia. *International Journal of Water Resources Development, 28*(3), 399–418.

Tarlock, A. D., & Wouters, P. (2007). Are shared benefits of international waters an equitable apportionment? *Colorado Journal of International Environmental Law and Policy, 18*(3), 523–536.

Taube, G., & Zettelmeyer J. (1998). *Output decline and recovery in Uzbekistan: Past performance and future prospects*. IMF Working Paper 98/132.

Teasley, R. L., & McKinney, D. C. (2011). Calculating the benefits of transboundary river basin cooperation: Syr Darya Basin. *Journal of Water Resources Planning and Management, 137,* 481–490.

United Nations Development Programme. (2009). Central Asia regional risk assessment: Responding to water, energy, and food insecurity. New York: United Nations Development Programme, Regional Bureau for Europe and CIS.

United Nations Economic Commission for Europe. (2011). Drainage Basins of the Aral Sea and other Transboundary Waters in Central Asia. New York: United Nations Publications.

Wegerich, K. (2004). Coping with disintegration of a river-basin management system: multi-dimensional issues in Central Asia. *Water Policy, 6,* 335–344.

Wegerich, K. (2005). What happens in a merger? Experiences of the state department for water resources in Khorezm, Uzbekistan. *Physics and Chemistry of the Earth, 30*(6/7), 455–462.

Wegerich, K. (2014). *Unpacking the disconnect of hydraulic mission and loss of water control: Three decades of external and internal changes and their implication for water management for the Irrigation Bureaucracy in Ferghana Province/Uzbekistan*. Project Report Irrigation Bureaucracy in Central Asia. Sri Lanka: International Water Management Institute (IWMI) and Water, Land and Ecosystems (WLE).

Wegerich, K., Kazbekov, J., Mukhamedova, N., & Musayev, S. (2012). Is it possible to shift to hydrological boundaries? The Ferghana Valley meshed system. *International Journal of Water Resources Development, 28*, 545–564.

Wegerich, K., Soliev, I., & Akramova, I. (2016). Dynamics of water reallocation and cost implications in the transboundary setting of Ferghana Province. *Central Asian Survey, 35*(1), 38–60.

Weinthal, E. (2002). *State making and environmental cooperation.* Cambridge: MIT Press.

Zeitoun, M., & Mirumachi, N. (2008). Transboundary water interaction I: Reconsidering conflict and cooperation. *International Environmental Agreements: Politics, Law and Economics, 8*(4), 297–316.

Zeitoun, M., Lankford, B., Krueger, T., Forsyth, T., Carter, R., Hoekstra, A., … Matthews, N. (2016). Reductionist and integrative research approaches to complex water security policy challenges. *Global Environmental Change, 39*, 143–154.