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 [1,2,3] which could generate greatest net as well as individual benefits [4,5,6,7,8,9,10,11]. 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 [4,5,6,7,8,9,10,11].

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 [10,14,15,16,17] 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 [8,9,10,11,17,18]. 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.

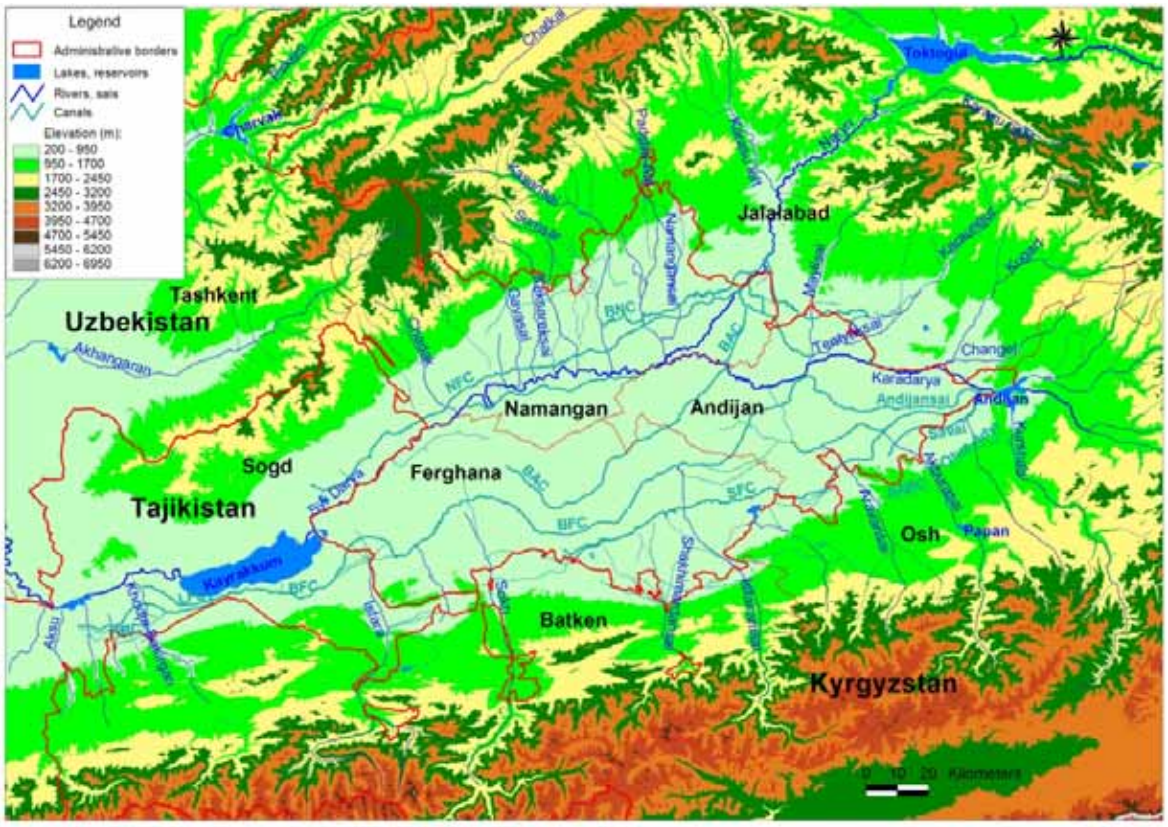

Figure 1. Topography, transboundary water resources and infrastructure in the Ferghana Valley (map by Alexander Platonov, 2015; courtesy of the International Water Management Institute).

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.

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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 [30,42,43,44,45,46,47].

Second, the extensive irrigation development placed emphasis on cotton independence of the USSR. The studies [28,30,31,42,43,44,45,46,47,48] 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.

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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.

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.