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Water Quantity and Quality in the Zerafshan River Basin: Only an Upstream Riparian Problem?

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ABSTRACT *In discussing the 1997 UN Watercourses Convention, McCaffrey (1998) gave a theoretical example of the late-developer problem. This paper complements that theoretical example with a real case study of the Zerafshan basin in Central Asia. While McCaffrey addressed the water quantity issue in his example, the focus here also includes water pollution. The aim of the paper is to analyze some of the provisions of the mechanisms in the field of international water law—the Helsinki Rules and the UN Watercourses Convention—for water quantity and quality aspects, as well as to provide an insight into the basin regarding these two aspects.*

Introduction

A number of multilateral environmental agreements could have been analyzed here—for example the 1971 Ramsar Convention, 1992 Convention on Biodiversity, 1994 Convention on Desertification, and the 1992 Convention on Climate Change. However, two mechanisms, the Helsinki Rules and especially the UN Convention on the Law of the Non-Navigational Uses of International Watercourses (UN Watercourses Convention) have, as Beaumont puts it, "the advantage of being broad in concept and encompassing all aspects associated with water use" (2000, p. 475). More importantly, Ziganshina (2009) shows that the Helsinki Rules and the UN convention may be indirectly and directly applicable to both of the riparian states in this case study. Tajikistan ratified the 1998 Moscow Agreement, which makes reference to the Helsinki Rules and directly to Uzbekistan; and Uzbekistan ratified the UN convention and is promoting it at international conferences.

During the time of the Soviet Union, the Central Asian Syr Darya, Talas, and Zerafshan Rivers, and parts of the Amu Darya, were within one country, and consequently these rivers could be managed according to hydrological boundaries, irrespective of the administrative boundaries of the constituent Soviet Socialist Republics (SSRs). The water resources of the region were not allocated equally among the riparian states. However, a benefit-sharing

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approach incorporating energy, water, and food products was in place within Central Asia (Wegerich, 2004; Granit *et al.*, 2012, this issue). With independence, the benefit-sharing approach disappeared and the resultant republican boundaries manifested the unequal development between upstream and downstream parts of the basin.

The potential for conflict over the use of natural resources in Central Asia and discussions on water disputes are certainly not new; they have been addressed by Tanton and Heaven (1999), Wegerich (2004, 2008), Wegerich *et al.* (2007), and Olsson and Bauer (2010). So far, however, few studies have been carried out regarding the inclusion of a water quality parameter in Central Asian transboundary river water management (Crosa *et al.*, 2006; Froebrich *et al.*, 2007; Olsson *et al.*, 2009).

Particularly within the Zerafshan basin, the disputes increasingly concern not only water sharing (Olsson *et al.*, 2010) but also water quality (Wegerich, 2010). At the beginning of the 2000s, pollution issues seemed to be the emerging cause of potential international conflict in the Zerafshan basin (Wegerich, 2011). Within the Zerafshan basin, downstream Uzbekistan is the main user of water resources; upstream, run-off is mainly generated in the territory of Tajikistan. Even though plans existed during the Soviet Union to divert the flow of the Zerafshan to irrigated areas within Tajikistan, as well as to develop the hydropower potential in the upstream Zerafshan, these plans were never realized; during that time, only mining was developed in upstream Tajikistan. Since the existing irrigation management was mainly based in downstream Uzbekistan, it appears that the resources of the Zerafshan were regarded rather casually by Uzbekistan as being primarily for its own use.

The next section of the paper provides a background to water availability and water utilization within the Zerafshan basin. The remaining part of the paper follows two story lines. One story provides the necessary background to the case study, first on current developments in the upstream basin and then on water quality and environmental impact. The other story line focuses on water-sharing and pollution issues within the Helsinki Rules and the UN Watercourses Convention. The last section brings these two stories together and draws some conclusions.

Water Availability from the Zerafshan Streamflow

The Zerafshan River basin is part of Central Asia's Aral Sea basin, which includes the Aral Sea and its main tributaries, the Amu Darya River in the south and the Syr Darya River in the north (Figure 1). The catchment area of the Zerafshan is approximately 143,000 km^2 and is divided into two parts, the upper narrow river valley in Tajikistan and the lower basin plains in Uzbekistan. The Uzbek part of the catchment alone covers an area of 131,000 km^2 (90%). The Zerafshan basin is of high importance for the water-based economy in Uzbekistan and Tajikistan. Approximately 10 million people live in the Zerafshan River basin—more than one-third of the population of Uzbekistan, plus 270,000 in Tajikistan—and the population is steadily growing.

The Zerafshan originates at 2,750 m above sea level in the Hissers Mountains of northern Tajikistan, flowing for its first 300 km in Tajik territory, and ends in Uzbekistan, after a total length of 870 km in the Bukhara region. Historically, the Zerafshan was a tributary of the Amu Darya. Because the Zerafshan is utilized mainly for irrigated agriculture in Uzbekistan and because the irrigated area has been expanded, the Zerafshan reaches neither the Amu Darya nor Bukhara today. The river has an annual average run-off

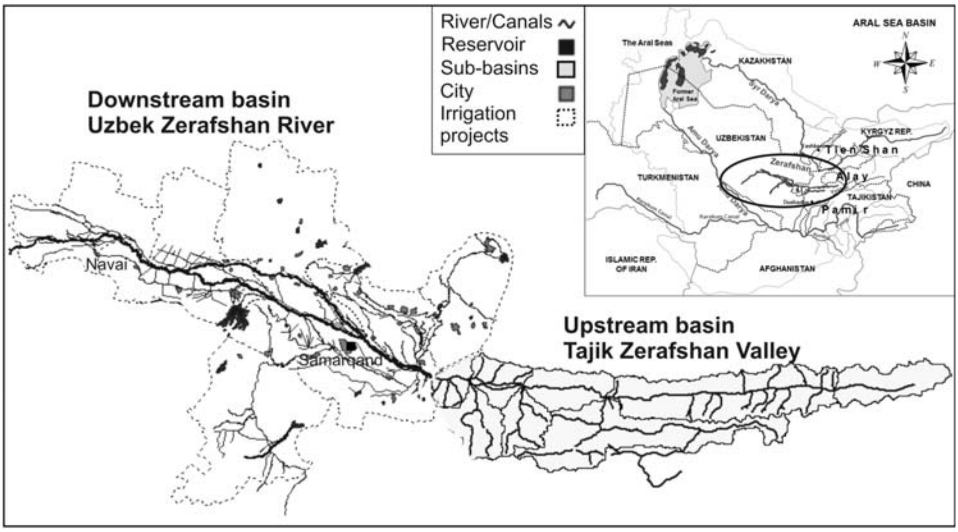

Figure 1. Location of the Zerafshan River and hydrological boundaries of the Tajik Zerafshan Valley (including sub-basins) upstream, and boundaries of the Uzbek irrigation projects downstream.

of 5.3 km^3, of which 97% (5.1 km^3) is generated in Tajikistan. The rise in the Zerafshan run-off begins in April/May and the maximum flow is reached in July of each year. As Figure 2 indicates, the highest discharges are in summer and the lowest in winter, independent of the general water availability. This specific flow regime with its maximum flood in summer has supported irrigation by providing water at the required time.

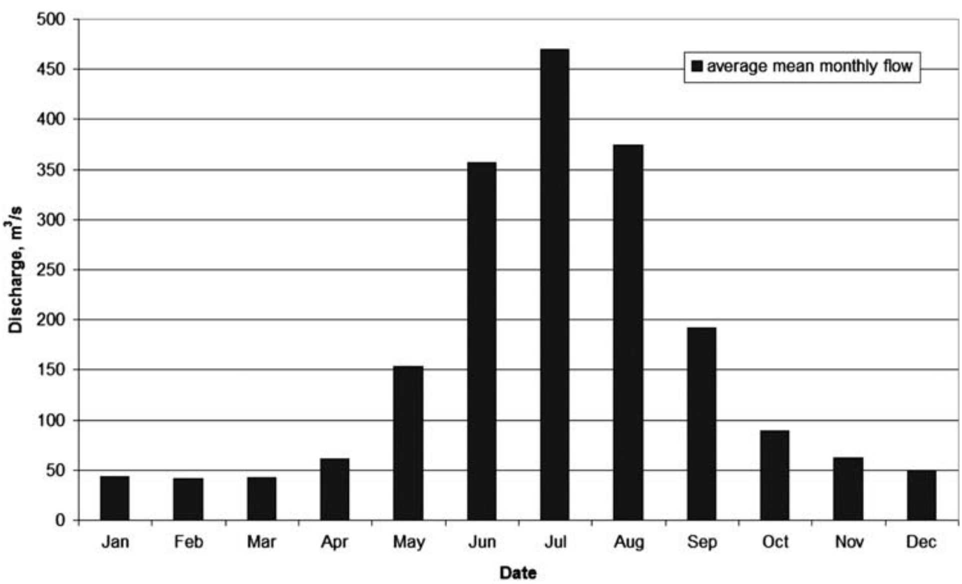

Figure 2. Averaged mean monthly flow for the Zerafshan River at Ravatkhoja, 1923–2007. *Source*: Uzbekistan Hydrometeorological Service UZGIDROMET

Currently, Tajikistan uses only approximately 6% (0.3 km^3) of the Zerafshan. Most of the Zerafshan run-off is utilized to irrigate about 550,000 ha in Samarkand, Navoi, Jizzak, and Kashkadarya Provinces. The irrigated land in the basin can be divided into Samarkand Province, (376,745 ha, 68%), Navoi Province (95,985 ha, 17%), Jizzak Province (49,238 ha, 9%), and Kashkadarya Province (29,995 ha, 6%). The annual water consumption for irrigation of this region is 6.6 km^3 (12,000 m^3/ha per year) and therefore 1.3 km^3 above the available mean run-off. To balance the higher irrigation demand, drainage water is reused. However, Ikramova (2009) reported water deficits in different areas for 2007 (Table 1).

Olsson *et al.* (2010) show an alteration in the flow regime, with significant increase in monthly flows in spring and decrease in summer. The summer flood, urgently required for the large irrigation projects downstream in Uzbekistan, is reduced, and more water is available in spring. Furthermore, on the basis of estimates of future discharges in 50 and 100 years, the hydrological changes will have an even greater effect on the seasonal water availability for irrigation. The authors indicated that the annual water availability is almost constant but the seasonal magnitudes of available run-off are changing. Hence, there will be more competition between upstream Tajikistan and downstream Uzbekistan. Planned projects within the basin might have to be reconsidered. Any future agreement on sharing the water resources of the Zerafshan should be flexible enough to incorporate changes in water availability.

Increasing Water Scarcity Due to Potential Water Utilization in the Upstream Basin

As already mentioned, the Soviet Union's plans to divert the flow of the Zerafshan to irrigate areas within Tajikistan and to develop the hydropower potential in the upstream Zerafshan never materialized. Currently in Tajikistan international organizations are focusing on livelihood strengthening and poverty reduction and the government is focusing on hydropower development in the upper Zerafshan basin.

Allouche (2007) makes special reference to the utilization of the Zerafshan water to increase the irrigated area. Recently, Schrader has mentioned the Ura-Tube diversion scheme, bringing water from the Zerafshan to Sogdh Province in the Ferghana Valley. According to him, of the total 132,000 ha of land available in Sogdh Province, only 30,000 ha are irrigated. He states that "the five presidents of the Central Asian States in their meeting in Nukus in 1993 included this potential project, amongst others, in the agreement" (Schrader, 2008, p. 32), the implication being that in 1993 Uzbekistan agreed to the Ura-Tube diversion scheme. Currently, this project is only identified as a long-term strategy. In 2006, the United Nations Development Programme (UNDP), in cooperation with the UK Department for International Development (DfID), was planning to start a programme with a focus on livelihood strengthening and poverty reduction in the upper

Table 1. Water shortages and utilization of drainage water, 2007 (ha).

	Irrigated area	Area with water shortages	Area using drainage water
Samarkand	376,745	2,950	17,801
Kashkardarya	29,995	20,532	0
Jizzak	49,138	70	0
Navai	95,985	1,080	3,316
Total	**551,863**	**24,632**	**21,117**

Zerafshan basin. The programme also incorporates changes from range land to agricultural land (UNDP, 2006). Hence, such projects are likely to increase the current water demand in the upper Zerafshan basin and therefore might have negative consequences for downstream Uzbekistan.

Recent publications mention the build-up of hydropower dams in the Zerafshan basin (Peyrouse, 2007). An MIE/UNDP report (2007) lists in total six hydropower projects (HPPs) as priority projects for the Zerafshan River. Schrader (2008) mentions former Soviet plans to establish a cascade of 14 smaller hydropower plants in the upper Zerafshan. Nevertheless, after a feasibility study by the Chinese company Sino Hydro on three locations, only the Yavan HPP was selected (height 90 m, active volume 0.03 km^3, dead volume 0.02 km^3). After Uzbekistan expressed concerns over ecology and possible future lack of water for irrigation, China withdrew from the project—but some of these projects were identified more than 20 years ago and Uzbekistan seems to have agreed to them in the past, so Tajikistan could possibly go ahead with them.

To be certain about the impacts of planned large- and small-scale water infrastructure projects on local water resources and the environment (e.g. the flood plains in nearby Penjikent and the Tugai forest), new studies have to be conducted, including newer agendas such as environmental and ecological flows and effects on ecosystem services. The most important biodiversity objects are in the Tugai riverine forest along the river course between Penjikent and Samarkand (on both sides of the border). Changes to the water regime, such as reduction of water amount or lowering of water level, reduced flooding of the riverine forest (which requires periodic floods), and changes in the seasonal water regime (not getting water during the naturally required periods, for example during the breeding season), would damage the Tugai forest and wildlife, which are parts of the watercourse ecosystems.

Water Quantity and the Problem of Being a Late Developer: The Helsinki Rules and the UN Watercourses Convention

Two of the most important and contentious rules governing international water relations are equitable and reasonable utilization and the no harm rule. In general, the principle of equitable and reasonable utilization is favoured by upper riparians, because it could be interpreted as providing more scope for upper riparians, which are often late-developer states, to claim their share. Conversely, lower riparians, often the first developers, tend to favour the no harm rule because it protects existing uses against impacts resulting from activities undertaken by the late developers, which are often the upstream states (Salman, 2007a).

However, there is a widespread assumption that harm can only "travel" downstream with the flow of the waters. Salman explains that "it is obvious, and clearer, that the downstream riparians can be harmed by the physical impacts of water quantity and quality changes caused by use by the upstream riparians" (2010, p. 351). He also explains, however, that it is actually a two-way matter: harm can be caused by downstream states too. By protecting their historic and existing uses, downstream states may block potential uses by upstream states. It is plausible that foreclosing the development plans of another state could harm its legal right to development. McCaffrey explains "it is not factual harm per se but injury to a legally protected interest" (2001, p. 347) that falls under the no harm rule.

The Helsinki Rules do not include a separate reference to the obligation not to cause harm, but rather specify it as one of the factors in determining equitable utilization. It should also be mentioned that the Helsinki Rules treat prior appropriation as one of the elements in determining equitableness: "the past utilization of the waters of the basin, including in particular existing utilization". In view of the fact that existing utilization has often triggered more population growth, including additional migrants, "whereas populations in depressed areas tend to be affected by emigration" (Wouters *et al.*, 2005, p. 96), it is reasonable to relate additional factors defining equity to prior appropriation, such as "the economic and social needs of each basin state; the population dependent on the waters of the basin in each basin state; [and] the comparative costs of alternative means of satisfying the economic and social needs of each basin state" (Helsinki Rules, 1966, Art. 5).

Non-existence of a separate provision in the Helsinki Rules on the no-harm rule has two possible explanations. At that time, there was perhaps no such notion as "water scarcity"; or perhaps upstream development was not a wide-spread concern for the international community, and therefore the level of competition was lower (Wegerich & Olsson, 2010). This point is also supported by the fact that the Helsinki Rules make reference first to the economic and then to the social needs of each basin state. Therefore, the Helsinki Rules have established the principle of reasonable and equitable utilization as the cardinal rule of international water law (Caflisch, 1998; Salman, 2007a).

In contrast to the Helsinki Rules, the UN Watercourses Convention explicitly states that the factors for defining equitable utilization include "existing and *potential uses* of the watercourse" (emphasis added). This may indicate that both actual and future uses are equally relevant. Nevertheless, Wouters *et al.* (2005, p. 104) state that "it is essential to point out that existing uses may have an implied priority over potential uses" (see also Shihata, 1998). Furthermore, unlike the Helsinki Rules, the UN convention has a separate article, Article 7, which specifically talks about the obligation not to cause harm and requires the state that causes significant harm to "take all appropriate measures, having due regard for the provisions of articles 5 and 6, in consultation with the affected State, to eliminate or mitigate such harm and, where appropriate, to discuss the question of compensation." Superficially, looking at this article, one could argue that only the actions of the upstream state would harm the downstream state, and therefore the upstream state should eliminate, mitigate, and compensate any harm. Arguably, however, the upstream state is not always the less powerful state. For instance, in the case of the USA and Mexico and the Colorado River basin, the co-riparians found a compensation mechanism incorporating two other basins in which the USA was in a different hydro-geographic situation. In this respect, it should be noted that the term "late developer" does not always have to encompass a whole country, but can be some areas within specific basins. Nevertheless, if one looks at developing, transition, or the BRIC countries (Brazil, Russia, India, and China), it is questionable whether demands for compensation would be voiced or met (e.g. on China within the Ili, Mekong, Ganges, and Brahmaputra, or on Turkey within the Euphrates and Tigris).

In light of the mentioned explanations offered by McCaffrey (2001) and Salman (2010), one could argue that the downstream state caused and continues to cause harm by foreclosure and therefore should compensate the upstream riparian state. Given the reasoning of Wouters *et al.* (2005), it seems unlikely that upstream states can claim compensation because of foreclosure by the early developer. As explained in the introduction, however, during the Soviet Union a benefit-sharing approach incorporating energy, water, and food products was in place within Central Asia. Hence, there were compensation mechanisms in place. It was only with independence that this benefit-sharing approach stopped.

Salman observes, "upper riparians still seem to consider the Convention as biased in favour of lower riparians because of its specific and separate mention of the obligation not to cause harm" (Salman, 2007b, p. 8). This is evidenced by the fact that the three countries that voted against the convention—Burundi, China and Turkey—are upper riparians.

Environmental Impact and Water Quality Patterns

Environmental degradation not only impedes sustainable development, but also endangers the health of human populations. Accurate assessment of the kind and extent of water pollution is a difficult task because of the diverse processes and complex phenomena characterizing these environments. In particular, in semi-arid and arid agricultural regions, water quality deterioration is a major pressure on water resources and the environment. Because of their hydrological and erosional behaviour, semi-arid regions are very vulnerable to pollution pulses. Large quantities of overland flow can erode the usually sparsely covered topsoil and transport nutrients, pesticides and heavy metals—dissolved and adsorbed—to rivers and receiving waters.

The most relevant environmental impacts in the Tajik upper catchment relate to (1) mining of rocks containing gold, silver, and copper; (2) processing of gold, silver, and copper in two plants in Aijni and Penjikent (Schrader, 2008; ZAR, 2009); and (3) the lack of any sanitation facilities for human or animal waste water. The amount of solid and sewage waste discharged into nature is not important, thanks to the small population living under very traditional conditions. With regard to sewage water discharge, the self-cleaning potential of land and surface water is functioning reliably. Discharged sewage waste is decomposed biologically due to the turbulence and high oxygen content of the Zerafshan River. The ZAR project—"Impact of transition processes on environmental risk assessment and risk management strategies in a Central Asian transboundary basin (Zerafshan), funded by the Volkswagen Foundation"—investigated the effect of the Anzob Mountain-Concentrating Combine (AMCC) on water quality status at two reference sites in the upper Zerafshan basin (upstream and downstream of the AMCC on the Yagnob river) in 2008 and 2009. The AMCC extracts and enriches complex mercury-antimonic ores from the Zerafshan-Gissar mercury-antimonic belt (the main ore minerals are antimonite and cinnabar). The industrial sewage is collected and stored in reservoirs and tailing ponds (total volume 3.0 million m^3) before the waters are discharged into the Yagnob River. The assessment found that no water quality parameter (in particular heavy metals) exceeded international limits (e.g. WHO, 2004, EU (1998) Directive 98/83 EC).

Nevertheless, the biggest concerns are about mining and in particular the dumping of chemicals after gold and silver processing. Since highly toxic compounds (e.g. cyanide—Schrader, 2008) have been stored for decades in special open ponds and do not receive any treatment, if a tailing pond dam were to burst, polluted sludge would be released from these sites and could contaminate the river basin. In the light of further planned projects (e.g. the Yavan HPP), questions have arisen from the Uzbek side as to whether these open ponds would harm the downstream basin. Accidents in the mining industry can be on a huge scale and leave a lasting impact on the environment. As a rule, these impacts are caused by flood events (Kraft *et al.*, 2006). In such cases, large amounts of processing sludge and tailings are moved from mining sites and reach rivers nearby. The bursting of a tailing pond dam could therefore lead to a devastating ecological disaster in the Zerafshan basin (e.g. river contamination, floodplain contamination in the Tugai forest, and sedimentation of contaminants in the Ravathodja Reservoir), as shown by Kraft *et al.* (2006) for a processing plant at a gold mine in Romania in 2000.

The environmental conditions are quite different in the lower Zerafshan basin in Uzbekistan. Relevant factors here include: (1) a high population of 6.5 million people, (2) intensive cultivation with use of fertilizers and pesticides (though these chemicals presently are not used in large amounts), (3) high salinity of drainage water from the large cultivation areas, and (4) processing of mining products in the Navoi chemical plant, and the resulting air and water emissions.

In summary, the environment is under much more pressure downstream than it is upstream. There is some additional industry in the Samarkand–Navoi–Bukhara region that, as a result of circumstances around the collapse of the Soviet Union, does not produce at all or only at very low levels. This has essentially reduced the contamination of soils and the pollution of air and water over the previous two decades.

The ZAR project investigated the current state of Zerafshan pollution in Uzbekistan for selected sites on the river downstream of Ravatkhodja, in the Samarkand and Navoi regions (Table 2).

The study found that river water quality declines in the middle and lower reaches as the river flows through the intensively irrigated agricultural regions, where water use is intensive and the river becomes a collector that receives the run-off of sewage and agricultural drainage water, industrial effluent, and municipal wastewater due to inefficient wastewater purification systems.

Water Quality in the International Rules: The Helsinki Rules and the UN Watercourses

Convention

Water pollution as a cause of harm to co-riparian states has been identified as one of the "new breed of claims" (Salman, 2006, p. 2), but water pollution had already been mentioned in the 1996 Helsinki Rules and the 1997 UN Watercourses Convention.

Table 2. Dangerous substances in the Zerafshan River.

River section	Drinking water standards exceeded[1]
Upper (downstream of Ravatkhodja Dam)	Phenols
Middle (downstream of Cheganak collector inflow)	Salts
	COD
	Phenols
	Water hardness
	Sulphates
Lower (downstream of Navoi chemical plant station)	Salts
	COD
	Phenols
	Water hardness
	Sulphates

[1] Per WHO 2004, EU Directive 98/83 EC.
Source: Ikramova (2009).

The Helsinki Rules declare in Article 10:

> Consistent with the principle of equitable utilization of the waters of an international drainage basin, a State:

(a) Must prevent any new form of water pollution or any increase in the degree of existing water pollution in an international drainage basin which would cause substantial injury in the territory of a co-basin State;
(b) Should take all reasonable measures to abate existing water pollution in an international drainage basin to such an extent that no substantial damage is caused in the territory of a co-basin State.

The UN convention declares, in Article 21(2) on prevention, reduction, and control of pollution:

> Watercourse States shall, individually and, where appropriate, jointly, prevent, reduce and control the pollution of an international watercourse that may cause significant harm to other watercourse States or to their environment, including harm to human health or safety, to the use of the waters for any beneficial purpose or to the living resources of the watercourse. Watercourse States shall take steps to harmonize their policies in this connection.

Article 10 of the Helsinki Rules makes reference to substantial injury and substantial damage in the territory of a co-basin State. Article 21 of the UN convention makes reference to significant harm to other watercourse states or to their environment. Given that the impacts of water pollution are mainly felt downstream, it seems reasonable to assume that these articles mainly protect the interest of the downstream state. However, as Wouters *et al.* point out, "normally impacts occur downstream as a result of water use upstream, but impacts in the reverse direction are also possible. For instance, the backwater from dams causes an upstream change, and dams may block the movement of migratory fish" (2005, p. 112). Downstream water diversion and pollution would also have impacts on migratory fish.

The 1994 Report of the International Law Commission (ILC) explains that "in applying the general obligation of article 7 to the case of pollution, the Commission took into account the practical consideration that some international watercourses are already polluted to varying degrees, while others are not. In light of this state of affairs, it employed the formula 'prevent, reduce and control' in relation to the pollution of international watercourses" (p. 123). If an upstream state wants to claim impacts on its environment from downstream pollution or constructions, Wouters *et al.* explain: "the consideration of impacts is complicated by the fact that the observed data may reflect the influence of existing impacts rather than the natural situation" (2005, p. 113). Furthermore, as the ILC Report explains, "a watercourse State can be deemed to have violated its due diligence obligation only if it knew or ought to have known that the particular use of an international watercourse would cause significant harm to other watercourse States" (1994, p. 104). Hence, even if a state had sufficient data on the "natural situation", it might be difficult to prove that at the time of pollution or construction the other state had knowledge about the significant harm caused. (This assumes that the same states, with the same boundaries, existed at the time of construction and pollution.)

Regarding pollution, it seems appropriate to look also at Article 20 of the UN Watercourses Convention, on protection and preservation of ecosystems:

> Watercourse States shall, individually or jointly, protect and preserve the ecosystems of international watercourses.

McCaffrey and Neville argue that "equality of right has been recognized in practice (if not in name) in international as well as domestic cases" (2010, p. 28). Article 20 of the UN Watercourses Convention also calls for "equality in obligations". The ILC Report reasons that "the general obligation of equitable participation demands that the contributions of watercourse States to joint protection and preservation efforts be at least proportional to the measure in which they have contributed to the threat or harm to the ecosystems in question" (p. 119). However, it might be difficult to determine in which proportion the riparian states have contributed to the threat or harm to the environment, especially when similar industries upstream or downstream could be potential polluters. Furthermore, if the environmental harm is mainly evident in the downstream riparian state, it is questionable how the upstream state could enforce the obligations of the downstream state to participate in protection. This is a very sensitive issue, because under international environmental law the bringing of any sort of claim by a state against another state requires a transboundary effect. An activity which is not causing transboundary harm is in general beyond the reach of international law; it is a purely domestic issue for the state concerned.

Although there is emphasis on equality of rights, the ILC report clearly states: "Of course, the duty to participate equitably in the protection and preservation of the ecosystems of an international watercourse is not to be regarded as implying an obligation to repair or tolerate harm that has resulted from another watercourse State's breach of its obligations under the draft articles" (p. 119). It even recognizes that "a requirement that existing pollution causing such harm be abated immediately could, in some cases, result in undue hardship, especially where the detriment to the watercourse State of origin was grossly disproportionate to the benefit that would accrue to the watercourse State experiencing the harm" (p. 122).

Conclusion

The Zerafshan basin gives a clear example of two riparian states that are upstream and downstream within one basin. The upstream riparian state can be classified as a late developer and the downstream state as an early developer within this basin. Because of basin closure, any water utilization development upstream will have an impact on the existing utilization of the downstream riparian state. Analysis of the Helsinki Rules and the UN Watercourses Convention shows that early developers' rights are strongly protected by the guiding principles of equitable utilization and not to cause significant harm. Although the UN convention specifically mentions potential uses, existing uses may have an implied priority over potential uses.

It is difficult to compare the different types of pollution from the two riparian states, but the presented data indicate that the current water pollution within Uzbekistan could be even higher than the transboundary water pollution from Tajikistan. With reference to equitable rights and obligations, the UN convention clearly highlights that each watercourse state is responsible for the pollution it causes. The fact that pollution of a river course travels downstream rather than upstream makes it more likely that upstream water pollution causes downstream harm rather than vice versa. In relation to downstream development which might have had an effect on the ecosystem and consequently might have had an impact on the upstream state, it was noted that these kinds of impacts (determination of natural flow) might be difficult to assess because of the influence of existing impacts.

From the case-study data, it is evident that the biggest future challenges in the Zerafshan basin are the alteration of the flow regime, the expected further water quality deterioration downstream, and the pollution risks upstream. Both water quantity and water quality issues will increase the competition between upstream Tajikistan and downstream Uzbekistan. However, to achieve more rational planning of future mitigation and management practices, water utilization and water pollution upstream and downstream should be considered equally in the basin framework. Hence, close cooperation is what will bring mutual benefits to upstream Tajikistan and downstream Uzbekistan.

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