Hydrological Sciences Journal

ISSN: 0262-6667 (Print) 2150-3435 (Online) Journal homepage: https://www.tandfonline.com/loi/thsj20

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**To cite this article:** Aibek Zhupankhan, Kamshat Tussupova & Ronny Berndtsson (2018) Water in Kazakhstan, a key in Central Asian water management, Hydrological Sciences Journal, 63:5, 752-762, DOI: 10.1080/02626667.2018.1447111

**To link to this article:** https://doi.org/10.1080/02626667.2018.1447111



Published online: 22 Mar 2018.

HYDROLOGICAL SCIENCES JOURNAL, 2018
VOL. 63, NO. 5, 752–762
https://doi.org/10.1080/02626667.2018.1447111



# Water in Kazakhstan, a key in Central Asian water management

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**ABSTRACT**

Central Asia is one of the regions with the highest probability of conflicts over water. Kazakhstan is the main Central Asian economic power and therefore it is important to understand how the country's water management policy is influencing water availability in the other Central Asian states. Already, the Central Asian economies are developing under increasing water deficiency, resulting in developmental problems. The main reasons for this are increasing political tensions and worsening ecological and socio-economic conditions. Kazakhstan was the first country in Central Asia to develop the pre-requisites for a transition towards integrated water resources management (IWRM). Therefore, Kazakhstan has potential to lead the development of trans-boundary water integration between all Central Asian states. A scenario for successful regional cooperation on water management in Central Asia involves establishing legal mechanisms for water management following international water law, assistance by international agencies and donors, and integrated social, economic and environmental methodology.

**ARTICLE HISTORY**
Received 23 August 2016
Accepted 19 February 2018

**EDITOR**
R. Woods

**ASSOCIATE EDITOR**
R. Hirsch

**KEYWORDS**
Kazakhstan; Central Asia; water availability; water management

## Introduction

The Republic of Kazakhstan, a former member of the Union of Soviet Socialist Republics (Soviet Union), became independent on 21 December 1991. Today, Kazakhstan is a unitary state with a presidential form of government and a parliamentary legislative body (Djalankuzov *et al.* 2004). It is the ninth largest country in the world, with a wide variety of climate and physiographical features. The country, with a population of approx. 17 million, borders Russia to the north, China to the east, Kyrgyzstan and Uzbekistan to the south, and Turkmenistan and the Caspian Sea to the west, and is one of the Central Asian states (Cowan 2007, Fig. 1). For administrative purposes, Kazakhstan is divided into 14 provinces (oblasts), namely, Akmola, Aktobe, Almaty, Atyrau, West Kazakhstan, Jambyl, Karagandy, Kostanai, Kyzylorda, Mangystau, South Kazakhstan, Pavlodar, North Kazakhstan and East Kazakhstan, and three cities (qalalar), namely, Almaty, Astana and Baykonyr. The largest part of the country is flat lowlands that are less than 500 m a.m.s.l. Deserts and steppes account for more than 80% of the total area (FAO 2016). The highest peak (Khan-Tengri) is about 7000 m a.m.s.l. in the Tien Shan Mountains to the southeast. The climate is mainly continental, with cold winters and hot summers. Average annual precipitation is only about 250 mm, with 315 mm in the northern areas and about 150 mm in the central parts. In mountainous areas, precipitation can reach up to about 880 mm/year (Djalankuzov *et al.* 2004, Yin *et al.* 2014, Xu *et al.* 2015). In total, 70–85% of annual precipitation occurs between October and April (FAO 2016). Climate change is likely to increase the water scarcity in the future. Observed temperature has risen twice as fast in Central Asia as compared to global levels since the 1970s (WBGU 2007). Projections of the Intergovernmental Panel on Climate Change (IPCC) show a clear increase in future temperature by 2–4°C for 2050 and 3–5°C for 2080 for most of the region (Lioubimtseva and Henebry 2009, IGES 2012, Lutz *et al.* 2013).

After its independence in 1991, Kazakhstan, like the other Central Asian states, experienced a breakdown of the economic system, and consequent socio-economic upheaval (Severskiy 2004). The transition from state-planned to market economy meant changing patterns of basic services such as water supply (Tussupova *et al.* 2015). By 2040, the total population of Central Asia will likely increase from today's 66 million to about 86 million (Siegfried *et al.* 2012). Kazakhstan's population will increase by about 22 million by 2040 (World Bank 2016). Together with countryside migration to urban areas, this is expected to put a huge stress on water and infrastructure. Water supply availability in Central Asia is a complicated problem due to the fact that the region's

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Figure 1. Kazakhstan in Central Asia, showing the eight main water basins (after UNDP 2016, Wikipedia 2016).

major rivers, the Syr Darya, Amu Darya and Irtysh, are all transboundary rivers. Thus, continual conflicts over the region's water resources have characterized the Central Asian states since the collapse of the Soviet Union (Dukhovny 2002a). At the same time, the Kazakhstan economy is developing under increasing water deficiency (Kamalov 2002, Kipshakbayev and Sokolov 2002, Ramazanov 2002, Ryabtsev and Akhmetov 2002). About 70% of developmental problems in the region are caused by freshwater shortages (Severskiy 2004). The main reasons for this are increasing political tensions and worsening ecological and socio-economic conditions (Bekturganov *et al.* 2016). These facts appear somewhat surprising since the totally renewable water resources (surface and groundwater) of Kazakhstan have been estimated at 100–117 km$^3$/year (FAO 2003, GWP 2009, MFA 2016). Of this total, water resources originating from outside of Kazakhstan correspond to 34–44 km$^3$/year. Thus, the total renewable water volume per capita per year is about 6490 m$^3$. Kazakhstan is, consequently, not water-scarce in terms of total water supply per capita (MFA 2016). However, the uneven distribution in space and time, in combination with excessive and often uncontrolled withdrawal for irrigation, create water scarcity especially in areas to the south. Figures are in any case uncertain due to great inter-annual variability and a general lack of long-term spatially distributed hydrological observation stations over a sparsely inhabited arid expanse. In general, groundwater resources are stated to constitute about 10–15% of surface water resources (MFA 2016). During the last decades of the 20th century, Kazakhstan and Central Asia suffered an immense ecological crisis. The Aral Sea, the fourth largest lake in the world, dried out (Micklin 2007). The reason for this was the doubling of irrigated agricultural area from 4.3 to 8.2 million ha. Due to the changed ecology, several hundred thousand square kilometres, having a population of several million, were damaged (Khvorog 1992, Small and Bunce 2003).

Due to the strategic geopolitical position, the hydropolitics and water management in Central Asia and Kazakhstan have gained increased interest during recent years. The sudden break-up of the Soviet Union and emergence of five sovereign Central Asian states sharing the two major rivers of Syr Darya and Amu Darya exposed a complex picture of water needs and potential political conflict (O'Hara 2000a, Bichsel 2011, Stucki *et al.* 2012). Water resources protection is a special challenge, not only for Kazakhstan, but for all the Central Asian states, in view of the fate of the Aral Sea and necessary agricultural expansion due to population increase in a future warmer climate.

In view of the above, the objective of this paper is to provide a critical state-of-the-art report regarding the water availability in Kazakhstan and the transboundary links with the other Central Asian states, with a discussion on possible ways forward regarding sustainable water use. In spite of the importance, there appears to be only a handful publications on these issues in the English-language scientific literature. On the one hand, this lack of information may reflect a general difficulty in assessing water resources availability over a large geographical arid and semi-arid expanse following the collapse of the Soviet Union. It is believed that this collapse was also followed by a breakdown in observational facilities of hydro-meteorological networks. On the other hand, much of this information may be limited to Russian scientific literature. Relevant data and information may also be available in unpublished documents and reports. The authors are, however, not aware of previous scientific publications trying to cover the situation on water availability in Kazakhstan and the transboundary links with the other Central Asian states. Along these lines, we try to summarize all available scientific literature and publically available reports on this subject, synthesise, and draw general conclusions for a sustainable future. Kazakhstan is the major economic power in Central Asia. Thus, the country may be seen as a leader of the economic development in the region. Since water is a major natural resource for all Central Asian states, the ability to use this resource in a responsible manner holds an important key to the peaceful and sustainable future of Central Asia. Accordingly, the paper first summarizes the history regarding water management that has led to the present water situation in Central Asia. The introductory section is followed by a review of available water resources and water management in Kazakhstan in view of climate change, including also some of the Russian scientific literature. Finally, we examine the present transboundary water situation between Kazakhstan, Central Asian states, and other transboundary water countries. We close with a conclusion and discussion on possible ways forward.

## Historical account of water management in Kazakhstan

Historically, water management constituted a key factor for the emergence, persistence and decline of civilizations in drylands, and Central Asia is a case in point for this (Abdullaev and Rakhmatullaev 2015, Karthe *et al.* 2015). The first account of water management in Central Asia is from Arabic historians and geographers in the 9–13th centuries (Le Strange 1905, Bartold 1914, O'Hara 2000b, Stucki *et al.* 2012). Irrigation systems were managed locally and linked to a single source of water (Gleason 1991). The Russian colonial conquest of Turkestan started about 1865 and, by the end of the 19th century, most of Central Asia was incorporated into the Russian Empire. The Stalin era (1929–1934) brought about Kazakhstan, with huge agricultural potential, but not much water supply. The Soviet administration developed and managed the region's water resources as a single integrated system (O'Hara 2000b). The water was considered as a common good to be used for the centrally determined production targets (Black *et al.* 1991). The water management and maintenance of irrigation systems during the Soviet period were inefficient, with large losses (Micklin 1991, O'Hara 2000b). Massive water losses occurred through seepage and evaporation along thousands of kilometres of unlined irrigation channels followed by water-logging and salinization. The collapse of the Soviet Union in 1991 resulted overnight in the Central Asian states having to take responsibility for management and maintenance of the vast, poorly managed and maintained water supply and irrigation systems. Problems occurred instantly due to lack of funding that prevented maintenance being carried out. The result was a rapidly deteriorating water distribution system (Linton 2010). In 1993, state *sovkhoz* farms and collective *kolkhoz* farms still dominated Kazakhstan's cultivated area by 92% (FAO 2016). Water management, in general, is closely linked to socio-economic, technological and political movements in society (Molle 2009, Swyngedouw 2009, Linton 2010). This is also true for Central Asia. Taking this approach, and the water management paradigm theory of Allan (2005), Abdullaev and Rakhmatullaev (2015) outlined a transformative framework for water management in the arid Central Asia region (Table 1).

The transformation from a planned, centralized economic system into a market-oriented system is ongoing. This transformation has dramatically changed the institutional, political and technical systems of water management in Central Asia (Rakhmatullaev *et al.* 2010, Abdullaev and Rakhmatullaev 2015). According to OECD (2007) the transition to a governance system based on integrated water resources management (IWRM) is ongoing. Integration is lacking due to (1) institutional and organizational weaknesses and a poor understanding of the information management in policy development and implementation, (2) structural and political constraints, and (3) resource constraints. Decentralization of the

**Table 1.** History of water management in Central Asia (after Abdullaev and Rakhmatullaev 2015).

| Period | Water management type |
|---|---|
| Until 1860s | Small-scale, community-based water management, nomadic irrigation schemes, individual farming |
| 1860–1920s | Decentralized and small-scale cotton production, simple irrigation schemes, small-scale basin transfer projects |
| 1920–1940s | Collectivization and nationalization, development of new irrigation projects, state influence on water sector |
| 1940–1990s | Hydraulic mission with mega construction of hydraulic infrastructures, inter-basin transfer projects, centralized economy, mechanization of agricultural production |
| 1990s–2016 | Sovereignty, market-oriented economy, decentralization of water and agriculture systems, IWRM, river basin management, transboundary water management |

water management has, for example, brought obligations of service delivery to local governments that are still lacking the capacity to fulfil this role (Garcia 2008, Abdullaev and Rakhmatullaev 2015). This is in line with findings from other transformation countries in Central and Eastern Asia (Dombrowsky *et al.* 2014, Abdullaev and Rakhmatullaev 2015, Karthe *et al.* 2015).

The present water resources management in Kazakhstan is based on the Water Code adopted by the Parliament in 1993 (Water Code of the Republic of Kazakhstan 2003). Eight water-related basin associations are responsible for water resources planning and management, water allocation, permissions, water diversion, reservoir regulation, control and registration (Sarsenbekov *et al.* 2016). In terms of hydrology, four major regions can be distinguished, namely the Ob River Basin draining to the Arctic Ocean, the Caspian Sea Basin, the Aral Sea Basin, and internal lakes, depressions or deserts (FAO 2016). The main water basins are Chu-Talas, Aral-Syr Darya, Balkhash-Alacol, Ural-Caspian, Nura-Sarysu, Tobol-Turgai, Irtysh and Ishim (Fig. 1).

Table 2 shows characteristics for each of these major water basins (United Nations Development Programme [UNDP] 2003, 2004, 2008, 2016, FAO 2016). The three values for mean renewable surface water are, from top to bottom: (a) basin generation of surface flow from precipitation on Kazakhstan territory; (b) inflow from upstream international basin areas; and (c) total actual volume including inflow secured by international agreements. For Chu-Talas Basin, with a total inflow of 6.74 km$^3$/year, 2.03 km$^3$/year have been secured by agreement with Kyrgyzstan. For Aral-Syr Darya Basin, a total inflow of 33.27 km$^3$/year corresponds to 27.42 km$^3$/year from Kyrgyzstan, 1.01 km$^3$/year from Tajikistan, and 4.84 km$^3$/year from Uzbekistan. In total, 10 km$^3$/year have been secured by agreement with Uzbekistan. For Balkhash-Alakol Basin, 12.01 and 0.36 km$^3$/year have been secured by agreement with China and Kyrgyzstan, respectively. For Tobol-Turgai and Ural-Caspian basins, 0.6 and 8.6 km$^3$/year, respectively, have been secured by agreement from the Russian Federation. For the Irtysh Basin, 9.53 km$^3$/year have been secured by agreement with China. Thus, the mean total basin internal generation of surface flow from precipitation is 56.5 km$^3$/year, inflow from upstream basin areas is 71.1 km$^3$/year, and total actual water volume including inflow secured by international agreements is 99.6 km$^3$/year (UNDP 2003, 2004, 2008, 2016, FAO 2016). However, these figures are uncertain due to short or incomplete hydrological records, but nevertheless give general guidance for the size of available water resources.

Groundwater is unevenly distributed throughout the country, with variable quality, and is mainly available in mountainous regions (FAO 2016). Exploration of groundwater is done with estimated reserves of about 16 km$^3$/year. It has been estimated that 33.9 km$^3$/year can be exploited, with a salinity of up to 1 g/L. About 57.6 km$^3$/year can be exploited, with a salinity up to 10 g/L (UNDP 2004, FAO 2016). Annual renewable groundwater resources are estimated to be about 33.85 km$^3$/year. About 26 km$^3$/year of these are overlapping with surface water. Thus, actual renewable water resources, including international water treaties, can be estimated to be about 107.8 km$^3$/year (FAO 2016).

By 2010, more than 200 water reservoirs had been constructed in Kazakhstan, representing a total volume

**Table 2.** Characteristics of major water basins in Kazakhstan (after UNDP 2003, 2004, 2008, 2016, FAO 2016).

| | Chu-Talas | Aral-Syr Darya | Balkhash-Alakol | Ural-Caspian | Nura-Sarysu | Tobol-Turgai | Irtysh | Ishim |
|---|---|---|---|---|---|---|---|---|
| Area (km$^2$) | 77 000 | 345 000 | 353 000 | 415 000 | 140 000 | 214 000 | 317 000 | 45 000 |
| Basin population (million) | 0.98 | 2.60 | 3.30 | 2.20 | 1.00 | 1.05 | 3.97 | 1.90 |
| Mean renewable surface water (km$^3$/year) | 1.20[a] | 3.30 | 16.40 | 5.30 | 1.70 | 1.50 | 24.50 | 2.60 |
| Mean renewable surface water (km$^3$/year) | 6.74[b] | 33.27 | 12.37 | 8.60 | 0 | 0.60 | 9.53 | 0 |
| | 3.23[c] | 13.30 | 28.77 | 13.90 | 1.70 | 2.10 | 34.03 | 2.60 |

[a] Basin generation of surface flow from precipitation on Kazakhstan territory;
[b] Inflow from upstream international basin areas;
[c] Total actual volume including inflow secured by international agreements.

of about 95.5 $km^3$ (UNDP 2008). A total of 48 262 lakes correspond to a water volume of 190 $km^3$. The largest of these is Lake Balkhash, with a volume of 112 $km^3$. Glaciers above 4000 m a.m.s.l., located in the south and east, correspond to 95 $km^3$ of water. Thus, the total water resources of Kazakhstan are estimated at about 539 $km^3$, comprising 190 $km^3$ in lakes, 100.5 $km^3$ in rivers, 95.5 $km^3$ in reservoirs, 95 $km^3$ in glaciers, and 58 $km^3$ in groundwater (UNDP 2004).

According to (FAO 2016), the total water withdrawal between 1995 and 2002 was 19.7–28.8 $km^3$/year; in 2010, it was 21.1 $km^3$/year. Of this, 14.0 $km^3$ (66%) was used in agriculture (irrigation, livestock and aquaculture), 0.88 $km^3$ (4%) for municipal use and 6.26 $km^3$ (30%) for industry. Of the total withdrawal, 19.0 $km^3$ (90%) was used from surface water, 1.0 $km^3$ (4.6%) from groundwater, 0.9 $km^3$ (4%) from desalinated water, 0.19 $km^3$ (0.9%) from treated wastewater and 0.11 $km^3$ (0.5%) from agricultural drainage.

An international agreement with Uzbekistan, Tajikistan and Turkmenistan was signed in February 1992 regarding water management of transboundary water resources (Ryabtsev 2016). This agreement stipulates that water supply for municipal needs is to be satisfied first. Thereafter, the needs of industry, energy and fish production may be met. No damage should be done to the other side, all riparian states should have equal rights on water use, and geographical location should not give any advantage. So far, Kazakhstan is the only Central Asian state that has joined the Convention on transboundary watercourses use and protection (Ryabtsev 2016).

Priorities regarding national development of water resources are defined in the Development Strategy of Kazakhstan by 2030 and the Strategic Development Plan of Kazakhstan by 2010 approved by the President's Decree No. 735 of 4 December 2001 (ADB 2005). These include protection and efficiency of water resources use in large river basins, salinity control, safe water supply with metering and water conservation techniques such recycling in agriculture and industry, and joint international transboundary water use.

## Water availability in Kazakhstan in view of climate change

Climate change is likely to have less effect on human vulnerability as compared to changes in land use and inefficient water management (Lioubimtseva and Henebry 2009). However, climate change will increase the region's vulnerability through the water supply and might contribute to water-borne and vector-borne infections. Central Asia is a particularly vulnerable region because of its geographical location, with mainly deserts and steppes and major agricultural dependence (Handmer *et al.* 1999, Adger *et al.* 2005, Lioubimtseva and Henebry 2009). Recorded temperature since the end of the 19th century indicates a significant warming trend for annual and winter temperatures (Jones *et al.* 1999, Lioubimtseva *et al.* 2005), which is approximately two times greater than the mean global warming, thus making Central Asia a "hotspot" of climate change (Malsy *et al.* 2012, Karthe *et al.* 2015). Similarly, precipitation shows a small decrease for the past 50–60 years (Adger *et al.* 2005). IPCC projections show a clear increase in future temperature by 2–4°C for 2050 and 3–5°C by 2080 for most of the region (Table 3; Lioubimtseva *et al.* 2005, IGES (Institute for Global Environmental Strategies) 2012). Precipitation projections appear less clear, but indicate a small increase up to 2050 and then a small decrease until 2085.

More than 90% of the total withdrawn water supply in Central Asia is used for irrigation (Abdullaev *et al.* 2006, Myagkov 2006). Farming irrigation corresponds to one-third of GDP and provides more than two-thirds of employment. Most of this water is taken from the big rivers. In order to preserve security of food and energy, water consumption will increase in line with population increase. This may lead to further friction between the Central Asian states (Ibatullin *et al.* 2009). Thus, climate change will affect water security for Kazakhstan. However, climate change is

**Table 3.** Climate change scenarios for Central Asia (Lioubimtseva *et al.* 2005, IGES (Institute for Global Environmental Strategies) 2012).

| Country | 2030 | 2050 | 2085 |
|---|---|---|---|
| Kazakhstan | T + 1.4°C, P + 2% | T + 2.7°C, P + 4% | T + 4.6°C, P + 5% |
| Kyrgyzstan | * | * | T + 4–6°C, P + 5% |
| Tajikistan | T + 0.5°C, P + 2% | * | * |
| Turkmenistan | * | * | T + 5°C, P + 30% |
| Uzbekistan | T + 1°C, P + 2% | T + 2°C, P + 4% | T + 3°C, P + 4% |
| Mean Central Asia | T + 1°C, P + 2% | T + 2–4°C, P + 4% | T + 3–5°C, P −2% |

T: temperature, P: precipitation, * no data.

likely to affect Kazakhstan mainly in an indirect way through increasing water needs from surrounding riparian states. This is further exemplified by vulnerability analysis for the Central Asian states. Kazakhstan is by far the least sensitive and exposed to climate change out of all the Central Asian states (World Bank 2009). The most vulnerable country in the region is Tajikistan, with virtually no adaptation capacity, followed, in order, by Kyrgyzstan, Uzbekistan and Turkmenistan.

Central Asia is experiencing a strong population growth (at present about 1.5% per year), which is expected to result in a 20-million increase by 2040 (Siegfried *et al.* 2012). This will require, for example, Uzbekistan to increase its irrigated area by 5–11% by 2020 (Abdullaev *et al.* 2009, Dukhovny and De Schutter 2011, Groll *et al.* 2015). This, in turn, will increase the water demand by 5–19%. However, due to climate change, with a projected increase in temperature of +2°C by 2030, vegetative periods will be longer and evapotranspiration rates higher. In turn, this will increase consumed water by 5% by 2030 and up to 16% by 2080 (Chub 2002, Agaltseva 2004, Aizen *et al.* 2006, Ibatullin *et al.* 2009, Groll *et al.* 2015). However, such global warming will also lead to reductions in Central Asian river flow by up to 50% by 2050, as glaciers decrease (Hagg *et al.* 2007, Bates *et al.* 2008, Lioubimtseva and Henebry 2009, World Bank 2009, Golubtsov and Lineitseva 2010, UN Economic Commission for Europe [UNECE] 2011). Given the above projections, it is clear that the Central Asian states are particularly susceptible to climate change. Irrigated agriculture relies largely on water resources supplied by the melting glaciers in the Pamir, Tien-Shan and Alay mountains. By 2030, it is estimated that available water resources will be 30% smaller compared to today, but the demand will have increased by 30% (Groll *et al.* 2015). Since the Central Asian water resources are largely shared, Kazakhstan's water security is deeply intertwined with other Central Asian states. Thus, water security in Kazakhstan can only be achieved together with proper water management for the whole of Central Asia (Janusz-Pawletta 2015). A way to achieve this is by IWRM. However, so far, efforts for Central Asian IWRM have not been very successful, as mentioned above (Dukhovny 2002b, Marat 2008, Boonstra and Hale 2010, Bichsel 2011, Groll *et al.* 2015).

Estimates of business-as-usual scenarios including climate change effects indicate that water demand will balance supply in Kazakhstan until the beginning of the 2020s. By about 2030, the demand could surpass the supply by 4 km$^3$/year, and by 2040, this deficit could have grown to 12 km$^3$/year (Groll *et al.* 2015). In this baseline scenario, it is assumed that economic demand for water resources will increase by 1.6% per year and reflect an increase by 50% in irrigation demand together with increase in water use by housing and utility services sectors and industry (Zhakenov 2014). From this, it is clear that water security is rapidly decreasing in Kazakhstan and that this is a major impediment for future development. The Kazakhstan water authorities envision that most of the future water deficit could be balanced by improving water-use efficiency and renovating the water infrastructure (Zhakenov 2014).

It is estimated that 78% of the urban population and >35% of the rural population in Kazakhstan have access to a varying degree of safe drinking water (GWP (Global Water Partnership) 2009, Bekturganov *et al.* 2016). In particular, the large distances from central water supplies and piped sewage systems pose difficulties, together with lack of maintenance. Bekturganov *et al.* (2016) and Tussupova *et al.* (2016) note that there is an urgent need to strengthen the environmental monitoring system as well as develop small-scale water supply and sanitation systems backed up by more efficient public spending.

## Transboundary water situation in Central Asia

As seen from the above description, solutions to the regional water problems in Central Asia are of paramount importance. However, the solutions are complex because of the transboundary nature of the main water resources, the major rivers in the region. The two largest rivers, the Amu Darya and the Syr Darya, together flow through all five countries. In particular, Turkmenistan and Uzbekistan are vulnerable because a major part of the water resources is generated outside of their respective territory (Table 4, GWP (Global Water Partnership) 2009). Uzbekistan is the country with smallest per capita water resources availability (1870 m$^3$/capita per year). Disputes over water are largely the result of an allocation policy rather than

**Table 4.** Total renewable water resources in Central Asian states (surface and groundwater; adapted from GWP (Global Water Partnership) 2009).

| Country | Total water resources (share of outside sources) (km$^3$/year) | m$^3$/capita per year |
|---|---|---|
| Kazakhstan | 117 (34) | 6 490 |
| Kyrgyzstan | 58 (0) | 8 480 |
| Tajikistan | 99 (16) | 13 500 |
| Turkmenistan | 25 (23) | 4 090 |
| Uzbekistan | 59 (34) | 1 870 |

scarcity of water supplies in the region (Gleason 2001). Actually, the World Bank has estimated that Central Asian states consume at least twice as much water as industrialized states (Zakhirova 2013).

Since Central Asian states share main rivers that cross their borders, upstream changes in water use will immediately be felt by downstream riparians. Water arising in Tajikistan and Kyrgyzstan represents more than 80% of the water that flows into the Aral Sea. These two countries are more interested in using available water resources for hydro-electric generation. Consequently, Tajikistan controls nearly 60% of the total storage capacity of the Amu Darya Basin and about 9% of the total storage capacity in the Syr Darya Basin by dams. Kyrgyzstan controls about 58% of the storage capacity in the Syr Darya Basin by reservoirs located on its territory. In contrast, Turkmenistan, one of the biggest consumers of water, has relatively few storage facilities and is almost entirely reliant on its upstream neighbours for water (Votrin 2003). The downstream riparians, Kazakhstan, Turkmenistan and Uzbekistan, however, want these water resources for irrigation. Consequently, upstream riparians want to discharge maximum volumes of water during winter when needs for electricity are peaking, while downstream riparians need the maximum amounts of water during summer and the irrigation period. This situation is worsened by population growth and climate change (Abdullaev *et al.* 2006).

Several agreements between Kazakhstan and neighbouring riparians regulate the use of transboundary water resources. An agreement on shared use and protection of transboundary water was signed between Kazakhstan and Russia in 1992 and later prolonged to 2007 (Ryabtsev 2016). Further, a Kazakhstan–Russian Commission has been established that holds regular meetings on water use. The agreement, however, does not include water quality. The Irtysh River flowing from China to Kazakhstan and Russia is heavily polluted by industrial and domestic wastewater.

In 2001, an agreement between Kazakhstan and China was signed on the collaboration and protection of transboundary water. Another agreement was signed in 2005 to warn against disasters that might occur in transboundary rivers. However, still no consensus has been reached regarding water allocation. China is expected to increase the irrigated areas and water withdrawal in its eastern regions. These may reach 15–20% of the total river runoff (including the Irtysh and Ily rivers among others (Ryabtsev 2016). Thus, areas such as Almata, East-Kazakhstan, Pavlodar, Karaganda and Akmola may experience future water deficit in this context. Water withdrawal from the Ily River may affect the metallurgy and energy industries as well as fisheries in a negative way. Also, Balkhash Lake may face further salinization due to reduced inflow (Stone 2012).

The real challenge, however, is the complex sharing of transboundary water resources with other Central Asian states (Zhupankhan *et al.* 2017). The contrasting interests and needs between upstream and downstream riparians are yet to be resolved. In the Syr Darya River Basin, peak flows during late winter and spring often threaten to flood downstream areas due to water release from the Toktogul hydropower plant in Kyrgyzstan. In contrast, water shortage often occurs during the summer in irrigated areas of the Makhtaaral region in South Kazakhstan. Uzbekistan is at present constructing several reservoirs in the Syr Darya Basin corresponding to about 2 $km^3$. This has been done without a general agreement with other Central Asian states and further decreases the inflow to the Aral Sea (Ryabtsev 2016). The construction of a reservoir in the Arnasay depression was done without the agreement of Kazakhstan. It creates backwater effects at the Shardara Reservoir in Kazakhstan, thus inflicting risks of overflow.

The general difficulty for Central Asia is a lack of coordination to resolve upstream–downstream transboundary water-related problems. Most established agreements do not address the detailed procedures for water problem solving. Integrated water problem solving involves national priorities regarding energy and agricultural production as well as environmental protection. In this respect, the national regulatory framework needs to adapt to international law (Ryabtsev 2016). Involving data sharing and information exchange is an integral part of this approach.

Unfortunately, cooperative organizations in the Central Asian region do not appear to be working effectively for efficient water management. Granit *et al.* (2010) argued that associations between sectors could represent opportunities for increased collaboration, e.g. border management, security, labour movements, trade, irrigation investments and water allocation along major river basins and between electricity trade, hydropower generation and water. This would represent a tangible suggestion to generate benefits and progress towards a regional power market with major benefits to the region. This would also ease the surging energy demands during wintertime in parts of the region (Granit *et al.* 2010).

## Discussion and conclusion

The Central Asian states share many common problems and unaddressed tasks in the management of water resources. UNECE (2013) notes that the Central Asian states increasingly are applying the principles of IWRM, but also that these efforts need to be broadened and deepened to fully exploit the benefits of IWRM in the region. Kazakhstan is in the process of developing river basin management plans for the eight major river basins in the country. In addition, inter-sectoral coordination bodies or mechanisms for water resources use are in the process of being established in Kazakhstan. The basin councils for the eight water basins include representatives from water users and NGOs. The representatives from civil society make up 2–19% and 30 are women (UNECE 2013). In general, environmental authorities play a minor role in water resources management. Consequently, legislative and controlling environmental authorities need to be strengthened and made more efficient. There is a general lack of integration between ministries, nongovernmental organizations and the public. By implementing IWRM, all ministries for environmental protection, agriculture, water resources, health, local governments, municipal authorities, nongovernmental organizations and representatives for industry can jointly solve water and environmental problems, create national action plans, as well as plans at regional and local levels.

Thus, IWRM is a way to make best use of the limited water resources of Central Asia. IWRM had its initial application in the Fergana Valley from the turn of the century (GWP 2014). Fergana Valley is a densely populated agricultural area between the Tian Shan in the north and the Alaj Mountains in the south. The valley is shared between Uzbekistan, Tajikistan and Kirgizstan. Fergana Valley is also one of the most socially tense regions in Central Asia. Applying IWRM to the region has not only reduced the total water volume used, but also significantly increased the total agricultural output. Thus, experience has shown that IWRM can provide a foundation for increasing water security. Kazakhstan was the first country in Central Asia to develop national prerequisites for a transition towards IWRM. Between 2000 and 2003, the key role for management of water was legally transferred to the Committee for Water Resources of the Ministry of Agriculture and the eight major water basins in the country (GWP (Global Water Partnership) 2014). In 2003, the new water legislation was in place. This top-down approach was successful down to the basin level. However, below basin level, the integration is still missing, because administrative officials are leading the basin water councils rather than elected stakeholders. Recent studies (Wegerich 2008, Zinzani 2015) confirm this impression. Local water associations below the basin level appear to receive less funding and support from the governmental level.

The above clearly shows that Kazakhstan has a leading role in the implementation of IWRM in Central Asia. Kazakhstan is the largest country with the majority of potential water resources and the leading economy in the region. It has taken a lead in the implementation of national IWRM and it could use its experience to lead development of transboundary water integration between all Central Asian states. However, this can only be developed once all the Central Asian states recognize the necessity of cooperating to efficiently use the water resources that they share (Mosello 2008). Scenarios for regional cooperation on water management in Central Asia involve: (1) establishing legal mechanisms for water management founded on international water law, (2) assistance by international organizations and donors, and (3) an integrated social, economic and environmental methodology (Khamzayeva *et al.* 2009, Janusz-Pawletta 2015).

The future for Central Asian development lies within the intertwined use of transboundary water resources. Upstream countries use water for hydropower while downstream countries use the water for agriculture and industry. Thus, water use also needs to integrate transboundary sectors. Upstream countries produce energy that downstream countries can use for agriculture and exploiting mineral resources. Once the international legal framework is in place and a political will is present, Central Asia can develop into a more efficient self-sustainable unit that also can better handle water negotiations with its powerful neighbours Russia and China.

## Disclosure statement

No potential conflict of interest was reported by the authors.

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