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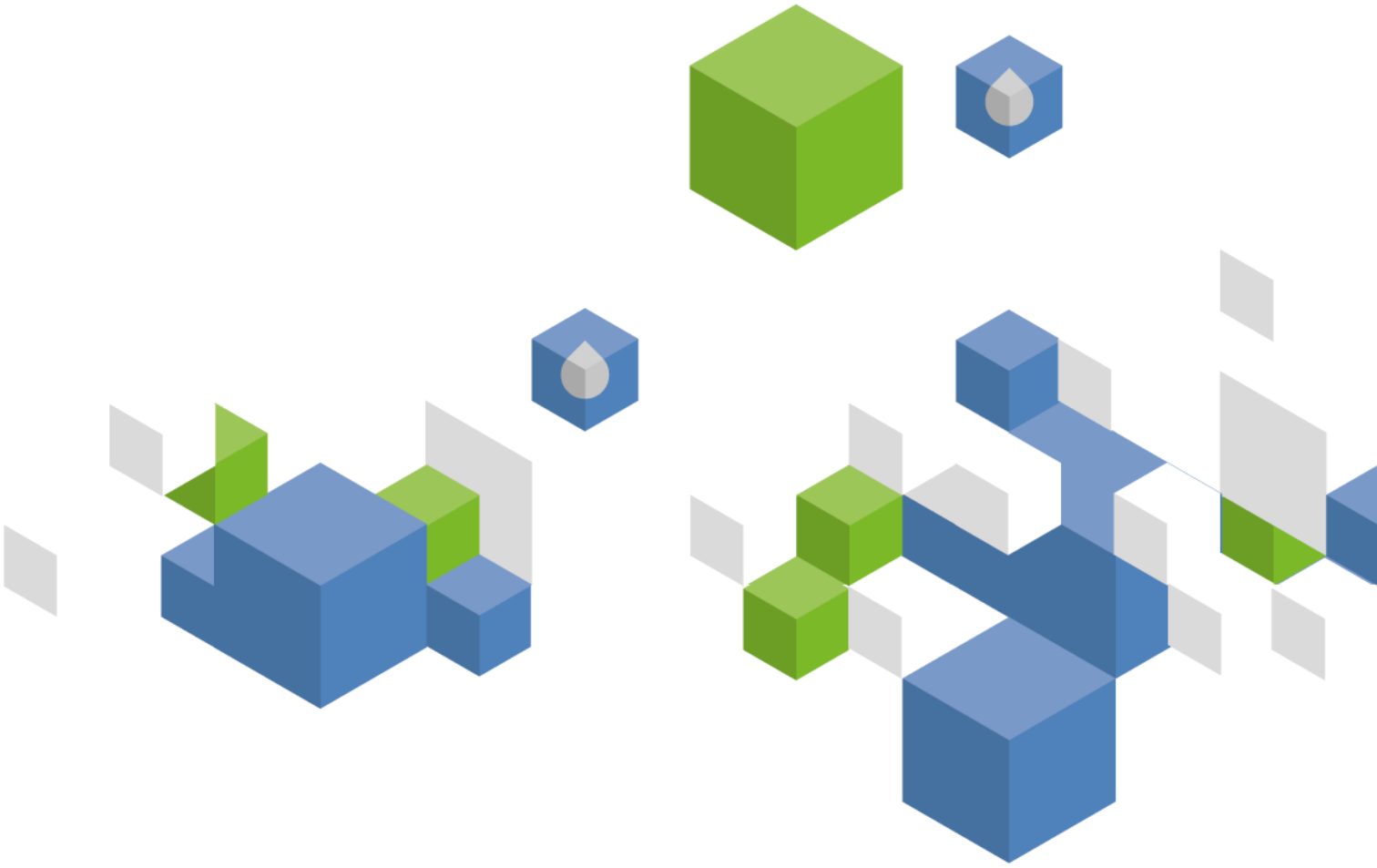

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Aral Sea transboundary river basin

GEOGRAPHY, CLIMATE AND POPULATION

Geography

The Aral Sea basin, total area 1.76 million km^2, is a transboundary river basin at the heart of the Eurasian continent. Geographically it covers an extensive area of Central Asia, most of Tajikistan (99 percent), Turkmenistan (95 percent) and Uzbekistan (95 percent), Osh, Djalal-Abad and Naryn provinces of Kyrgyzstan (59 percent), Kyzylorda and South Kazakhstan provinces of Kazakhstan (13 percent), northern Afghanistan (38 percent) and a very small part of the Islamic Republic of Iran in the Tedzhen/Murghab basin (not included in Table 1).

TABLE 1
Country areas in the Aral Sea river basin

Basin	Area		Countries included	Area of country in basin (km^2)	As % of total area of the basin	As % of total are of the country
	km^2	% of Central Asia				
Syr Darya	531 650	11	Kazakhstan	345 000	64.9	12.7
			Kyrgyzstan	110 570	20.8	55.3
			Tajikistan	15 680	2.9	11.0
			Uzbekistan	60 400	11.4	13.5
Amu Darya	1 023 610	22	Afghanistan	166 000*	16.2	25.4
			Kyrgyzstan	7 800	0.8	3.9
			Tajikistan	125 450**	12.3	88.0
			Turkmenistan	359 730	35.1	73.7
			Uzbekistan	364 630**	35.6	81.5
Tedzhen-Murghab	182 010	4	Afghanistan	80 000	44.0	12.3
			Turkmenistan	102 010***	56.0	20.9
Aral Sea basin	1 737 270	37	Afghanistan	246 000	14.2	37.7
			Kazakhstan	345 000	19.9	12.7
			Kyrgyzstan	118 370	6.8	59.2
			Tajikistan	141 130	8.1	99.0
			Turkmenistan	461 740	26.6	94.6
			Uzbekistan	425 030	24.5	95.0

* *Includes 75 000 ha of Northern basin*
** *Includes the Zeravshan basin*
*** *55 155 ha of Tedzhen river basin and 46 855 ha of Murghab river basin*

The territory of the Aral Sea basin can be divided into two main zones: the Turan plain and the mountain zone. The Kara Kum covers the west and northwest of the Aral Sea basin within the Turan plain and Kyzylkum deserts. The east and southeast are in the high mountains of the Tien Shan and Pamir ranges. The remaining portion of the basin is composed of various types of alluvial and inter-mountain valleys, arid and semi-arid steppe. In all the regions the different forms of relief have created specific conditions that are reflected in the interrelation between water, land and people.

About 90 percent of Tajikistan and Kyrgyzstan is mountainous. More than half the mean annual runoff in the Aral Sea basin is generated in Tajikistan and almost one-quarter in Kyrgyzstan. A significant feature of the region is the number of oases (Fergana valley, Khorezm, Tashaus, Mary, Zeravshan, Tashkent – Chimkent), which cover a small part of the overall area. Since ancient times these oases have been at the centre of human activity because of their favourable living conditions (water, precipitation, the best soils, etc.). More than 50 percent of Kazakhstan, Turkmenistan and Uzbekistan are covered by

Figure 1
Aral Sea River Basin

desert, less than 10 percent is mountainous. Just over 10 percent of the mean annual runoff in the Aral Sea basin is generated in these three countries.

The Aral Sea basin includes the Syr Darya and Amu Darya, the Tedzhen (known as Hari Rod in Afghanistan) and Murghab rivers, the Kara Kum canal linking the Amu Darya, Murghab and Tedzhen rivers, shallow rivers flowing from Kopet Dag and western Tien Shan, as well as the areas with no runoff between these rivers and around the Aral Sea. In Kazakhstan, the flows from the Torgai, Sarysu, Chu and Talas rivers are lost in the desert or are directed to natural depressions. These rivers are not considered part of the Aral Sea basin.

Before 1960, the Aral Sea ranked as the world's fourth largest lake, after the Caspian Sea, the Great Lakes in North America and Lake Chad, since then it has been progressively drying up (Figure 1).

Climate

The climate is continental, determined by the landlocked position of Central Asia within the Eurasian continent. Large daily and seasonal temperature differences are characteristic of the region, with high solar radiation and relatively low humidity. Terrain and altitude range from 0 to 7 500 m above sea level (asl), leading to greatly diversified microclimates. Although this area is often subject to humid winds, the mountains trap most of the moisture, leaving little precipitation for the other areas of the Aral Sea basin (CAWaterInfo, 2011).

The average temperatures range from 0–4 ºC in January and 28–32ºC in July. In some areas, summer temperatures may be as high as 52 ºC and winters as cold as minus 16ºC, with an absolute minimum of minus 38ºC, creating a sharply contrasting overall climate, with hot summers and cold winters (Murray-Rust et al., 2003).

Annual precipitation in the lowlands and valleys is between 80 and 200 mm, concentrated in the winter and spring, while on the foothills precipitation is between 300 and 400 mm, and on the southern and southwestern sides of the mountain between 600 and 800 mm.

Because of the large differences in summer air humidity between the ancient oases and the newly irrigated areas, 50–60 percent and 20–30 percent respectively, water demands in the former desert – now under irrigation – are significantly higher than around the oases. The second factor, which particularly affects agricultural production, is the instability of spring temperatures and precipitation. Late frosts may occur at the beginning of May with hail in June, which sometimes destroys emerging cotton plants and vegetables over large areas (CAWaterInfo, 2011).

Population

The Aral Sea basin is a diverse region with approximately 46 million people in 2006 while in 1960 and 1980 the population was 15 million and 27 million people respectively (Sokolov, 2009). In 2010, access to improved water sources varied from 50 percent in Afghanistan to 96 percent in the Islamic Republic of Iran (Table 2).

TABLE 2
Access to improved water sources (Source: JMP, 2011)

Country	Access to improved water sources (% of population)		
	National	Urban	Rural
Afghanistan	50	78	42
Islamic Republic of Iran	96	97	92
Kazakhstan	95	99	90
Kyrgyzstan	90	99	85
Tajikistan	64	92	54
Turkmenistan	84	97	72
Uzbekistan	87	98	81

WATER RESOURCES

Mountains and glaciers play an important role in water storage. They can store precipitation as snow and ice in winter and deliver it as snow melt to rivers and associated alluvial aquifers during the dry summer season (July and August) (Rakhmatullaev et al., 2009).

Surface water

The two major river basins in the Aral Sea basin are the Amu Darya in the south and the Syr Darya in the north. A third river basin, the Tedzhen-Murghab basin, is located in the southwest. Some thirty primary tributaries feed the basins. However, today, many of the tributaries only flow seasonally – drying up before reaching the main rivers.

The main rivers originate in mountainous regions – the Pamir and Tien Shan ranges – where there is surplus moisture (precipitation of 800–1 600 mm and potential evapotranspiration of 100–500 mm), resulting in permanent snowfields and glaciers (Murray-Rust et al., 2003).

Amu Darya basin

The Amu Darya basin is divided into two unequal parts: the smaller upstream to the southeast, characterized by the high mountain ranges of Central Pamir and Tien Shan with an altitude of 5 000–6 000 m, and the larger area downstream to the northwest, where plains dominate the landscape and elevations are no higher than 200 m. Despite the very arid conditions of the region, the high mountain ranges facilitate the formation of important water-courses that behave as a huge feeding reservoir (Rakhmatullaev et al., 2009).

The Amu Darya is the longest river in Central Asia and the second longest in Afghanistan. Six countries share the river Afghanistan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan. Rising in Afghanistan, Kyrgyzstan and Tajikistan, the Amu Darya flows 2 540 km from the headwaters of the Panj (Pyandzh) to the Aral Sea. The river is named Amu Darya from the point where the Panj river joins the Vakhsh river in the Pamir mountains.

The Vakhsh river rises in Kyrgyzstan, where it is named the Kyzyl Suu. This is the longest river in Tajikistan, crossing from the northeast to the southwest, its catchment area lies at over 3 500 m in the highest part of Tajikistan. The Vakhsh river takes its name from the confluence of the Surkhob and Obikhingob rivers. The Panj river, the largest tributary of the Amu Darya, originates in the Pamir mountain ranges and forms the border between Tajikistan and Afghanistan for almost its entire length flowing from east to west. After the confluence of the Panj and Vakhsh rivers, it becomes the Amu Darya and about 100 km further downstream it leaves Tajikistan to become the border between Afghanistan and Uzbekistan.

The Kofarnihon river rises in Tajikistan and flows into the Amu Darya about 36 km downstream of the confluence of the Panj and Vakhsh rivers. The Kofarnihon river flows mainly in Tajikistan and forms the border between Tajikistan and Uzbekistan over a short distance before flowing into the Amu Darya. Two other large right tributaries, the Surkhandarya and Sherabad rivers, and two left tributaries, the Kunduz and Kokcha rivers, flow into the Amu Darya in the middle reach. Further downstream towards the Aral Sea, the Amu Darya has no tributaries.

Two rivers, the Zeravshan and Kashkadarya rivers, are similar to the Amu Darya for their water catchment characteristics however; they no longer discharge into the Amu Darya (Rakhmatullaev et al., 2009). The Zeravshan, which rises in Tajikistan, used to be the largest tributary of the Amu Darya before it began to be tapped for irrigation, mainly by Uzbekistan. Now the Zeravshan evaporates in the Kyzylkum desert near the city of Bukhara. Total river flow from Tajikistan to Uzbekistan is 3.09 km^3/year; all these water resources are allocated to Uzbekistan.

In Afghanistan, the rivers of the northern basin originate on the northern slopes of the Hindu Kush and flow northwards towards the Amu Darya river. However, most of these rivers die out on the Turkistan plains before reaching the Amu Darya. From west to east, the main rivers include the Shirin Tagab, the Sarepul, the Balkh and the Khulm rivers.

The Amu Darya is fed largely by water from melted snow, thus maximum discharges are observed in summer and minimum in January-February. This year-round availability of the flow favours the use of the river water for irrigation during the dry summer. While crossing the plain, from Kerki in Turkmenistan to Nuqus in Uzbekistan, the Amu Darya loses most of its flow to evaporation, infiltration and irrigation withdrawal. The basin's total long-term average annual runoff is 78.46 km^3. The long-term average annual flow in the Amu Darya basin from Kyrgyzstan to Tajikistan – through the Kyzul Suu river – is 1.93 km^3 or about 2 percent of the total flow of the Amu Darya.

The main flow of the Amu Darya originates in Tajikistan: about 59.45 km^3, including 3.09 km^3 of the Zeravshan river, or 76 percent of the total flow. The Amu Darya then flows along the border between Afghanistan and Uzbekistan, across Turkmenistan and returns to Uzbekistan where it discharges into the Aral Sea. About 11.7 km^3 (not including 1.9 km^3 of the northern basin, which mainly evaporates before reaching the Amu Darya) or 15 percent of Amu Darya water is formed in Afghanistan. The internal contribution of Turkmenistan to the river is 0.68 km^3 or 1 percent. The internal contribution of Uzbekistan to the river is 4.7 km^3 or 6 percent.

The share of the Amu Darya flow allocated to Turkmenistan and Uzbekistan is 50 percent each of the actual river flow at the Kerki gauging station. This share is based on an agreement between Uzbekistan and Turkmenistan signed in January 1996, which supplemented the 1992 Agreement signed by the five Central Asian countries. The Turkmen and Uzbek allocation corresponds to 42.27 percent of the share of the Amu Darya surface water resources on which agreements have been concluded. The agreements are calculated based on about 67 percent of the total flow produced in the Amu Darya basin, which is on average 78.46 km^3/year. This is calculated by adding the long-term average annual internal renewable surface water resources (IRSWR) of the basin in the different countries: Kyrgyzstan 1.93 km^3, Tajikistan 59.45 km^3, Uzbekistan 4.70 km^3, Afghanistan 11.70 km^3 and Turkmenistan 0.68 km^3.

The actual surface water resources allocated to Turkmenistan and Uzbekistan are calculated every year, depending on the actual flow. On average, water resources allocated to Turkmenistan in the Amu Darya basin are about 22 km^3/year, including 0.68 km^3/year of IRSWR, and 22 km^3/year to Uzbekistan, which includes 3.09 km^3 of the Zeravshan river. Even though Afghanistan is not part of the five states of the Former Soviet Union, and therefore not part of the agreement, allocations between the five states include the flow of 11.7 km^3/year, which is measured at Kerki station in Turkmenistan.

Syr Darya basin

The Syr Darya is the second most important river in Central Asia for water resources it flows 3 019 km from the Naryn headwaters in Kyrgyzstan. The Syr Darya originates in the Tien Shan mountains, runs through the upstream countries of Kyrgyzstan and Tajikistan and then through Uzbekistan and Kazakhstan into the Aral Sea (Murray-Rust et al., 2003). The river is known as the Syr Darya after the point where the Naryn joins with the Karadarya in Uzbekistan. Glaciers and snow melt feed the river, mostly the latter. The water regime is characterized by a spring-summer flow, which begins in April. Discharge is highest in June.

The total long-term average annual runoff of the Syr Darya basin is 36.57 km^3. About 27.42 km^3 or 75 percent is formed in Kyrgyzstan, which is the flow from Kyrgyzstan to Uzbekistan, of which 22.33 km^3 is secured by agreements. Of this, 11.8 km^3/year is transit flow to Tajikistan secured by agreements. Only 3 percent of the Syr Darya is generated within Tajikistan by the shallow rivers Khodzhabakirgan, Isfara and Isfana, with a total flow of 1.01 km^3/year. The annual flow at the border between Tajikistan and Uzbekistan, is 11.54 km^3 of which 10 km^3 is transit flow to Kazakhstan, as secured by agreements.

On average, the contribution of Uzbekistan to the Syr Darya is 4.84 km^3 or 13 percent, and the contribution of Kazakhstan is 3.3 km^3 or 9 percent.

The largest tributaries of the Syr Darya within Kazakhstan are the Keles, Arys, Badam, Boroldai, Bugun and smaller rivers, flowing from the southwestern slopes of the Karatau ridge.

Tedzhen-Murghab basin

Afghanistan is the source of the Murghab and Tedzhen rivers of the Aral Sea basin. They terminate in Turkmenistan, although the Tedzhen also travels across the Islamic Republic of Iran (Horsman, 2008). The main flow of the Tedzhen and Murghab together is 3.1 km^3 in Afghanistan and 0.3 km^3 in Turkmenistan. The Tedzhen waters are covered by a treaty, signed in February 1926 between the Islamic Republic of Iran and Turkmenistan, which remains in force. This treaty stipulates that each year Turkmenistan receives a quantity equal to 70 percent of the total Tedzhen average runoff, which corresponds to an average of 0.75 km^3.

Aral Sea basin

The total mean annual flow of all rivers in the Aral Sea basin is an estimated 118.43 km^3 (Table 3). In accordance with flow probabilities of 5 percent (wet years) and 95 percent (dry years), the annual flow ranges from 108 to 47 km^3 for the Amu Darya river and from 54 to 21 km^3 for the Syr Darya river respectively.

TABLE 3
Mean annual runoff in the Aral Sea basin (km^3/year)

Country	River basin			Total Aral Sea basin	
	Syr Darya	Amu Darya	Tedzhen-Murghab	km^3	%
Kazakhstan	3.30			3.30	2.8
Kyrgyzstan	27. 42	1.93		29.35	24.8
Tajikistan	1.01	*59.45		60.46	51.0
Turkmenistan		0.68	0.3	0.98	0.8
Uzbekistan	4.84	4.70		9.54	8.1
Afghanistan		11.70	3.1	14.80	12.5
Islamic Republic of Iran			n.a.	-	-
Aral Sea basin	**36.57**	**78.46**	**3.4**	**118.43**	**100**

n.a. *not available*
* *Includes 3.09 km^3 of Zeravshan river*

There are no significant anthropogenic changes in the upstream zone of flow formation. However, because of the construction of large dams on the border of this area, the downstream runoff regime is changing. Because of significant losses in the desert areas, and because of major agricultural water withdrawal, the flow reaching the Aral Sea is limited to a small percentage of these annual flows. In the driest years this corresponds to less than 10 percent for Amu Darya and less than 5 percent for the Syr Darya.

Groundwater

The groundwater resources of the Aral Sea basin can be divided into two parts: the natural flow or primary freshwater from the mountainous and water catchment areas, and groundwater filtrated from hydro-technical structures and irrigated land (secondary freshwater). Estimated reserves of Central Asia countries (Afghanistan not included) are about 31.1 km^3, of which 14.7 km^3 are in the Amu Darya basin and 16.4 km^3 in Syr Darya basin. Because exploitation of groundwater may impact surface water flows, the quantification of groundwater resources must be carefully carried out to identify the portion of the reserves that can be used without significantly diminishing surface runoff. The reserves confirmed for extraction are an estimated 13.1 km^3 per year (CAWaterInfo, 2011).

Average annual groundwater recharge in Afghanistan is an estimated 2.97 km^3 in the Amu Darya basin, 0.64 km^3 in the Tedzhen basin and 2.14 km^3 in the Murghab and northern basins. In Kyrgyzstan groundwater recharge is an estimated 0.23 km^3 in the Amu Darya basin and 5.25 km^3 in the Syr Darya basin. Average annual groundwater recharge in Uzbekistan, which is entirely located in the Aral Sea basin, is an estimated 8.8 km^3, while in Tajikistan it is 6 km^3. There are no detailed figures by basin for Kazakhstan and Turkmenistan. It should be noted, however, surface water and groundwater resources cannot be added to obtain total renewable water resources. This is because of the overlap between surface water and groundwater as a result of seepage from rivers into aquifers and groundwater drainage into rivers (base flow of rivers).

Natural lakes, reservoirs and non-conventional sources of water

There are many natural lakes in the mountainous areas and ravines of Central Asia. Most of the large lakes occupy basins that resulted from tectonic activity (Issyk-Kul, Song-Kel, Chetir-Kel, Karakul, Sarichelek). Lakes resulting from landslides, caused by earthquakes, are the Sarez and Yashinkul in the Pamir mountains. Numerous lakes are of glacial origin; one of the largest is the Zorkul, located at 4 125 m in the Eastern Pamir. Karst lakes are also present. In the mountains, lakes are usually freshwater or slightly saline, depending on the quality of inflowing water. Initial assessments of freshwater reserves in mountain and lowland lakes suggest a volume of 60 km^3 (CAWaterInfo, 2011).

Many artificial lakes have been created, most are shallow. The largest of these lakes in the region are Sarykamish, in the lower reaches of the Amu Darya and Aydarkul, in the middle reach of the Syr Darya. Large volumes of water are discharged into Aydarkul lake during high water years from the Chardarya reservoir, on the border between Kazakhstan and Uzbekistan. In the last few years, this has been common practice in winter to create energy from the Naryn-Syr Darya hydropower cascade. The volume of water resources found in artificial lakes is an estimated 40 km3 (CAWaterInfo, 2011).

Return flow forms a high proportion of water resources in the basin and is a major source of pollution. In recent years, the annual mean values of return flow, comprised of drainage water from irrigation and wastewater from industry and municipalities have varied between 28 km^3 and 33 km^3. About 13–15.5 km^3 annually form in the Syr Darya basin, and about 15–18 km^3 in the Amu Darya basin. The total amount makes up about 95 percent of drainage water and about 5 percent of untreated municipal and industrial wastewater. The high percentage of drainage water demonstrates that irrigation actually consumes only about 45–50 percent of total agricultural withdrawals (CAWaterInfo, 2011). In 1993, about 6 km3 of agricultural drainage water or wastewater were directly used for irrigation.

One of the principal goals of water managers is to minimize losses. Drainage water is highly saline: 2–3 g/litre from April to September and 5–12 g/litre during autumn and winter. The quality of the drainage effluent depends on the location of the irrigation scheme within the river basin – upper, middle, or lower reaches – and the leaching requirements of the irrigated area. It also depends on the use of agrochemicals. Local salt mobilization is determined in part by the type of drainage system (open, subsurface or vertical), seepage, drain spacing and drain depth. The poor quality limits the direct use of drainage water, especially for irrigation. Only about 15 percent of total return flow is directly used and more than 55 percent returns to rivers. About 30 percent ends up in natural depressions, from which the water evaporates (CAWaterInfo, 2011).

WATER-RELATED DEVELOPMENTS IN THE BASIN

Agriculture

The rural population in the Aral Sea basin is mainly employed in farming. Out of 60 million ha that are considered cultivable (Afghanistan and the Islamic Republic of Iran are not included) only about 10 million ha are actually used. Half of the actually cultivated land is located on the fertile soils of the oases, which are naturally drained. The other half requires complicated and expensive reclamation

measures before it can be used, including drainage and land levelling and improvement of the soil structure. Land availability varies greatly between the countries. Kazakhstan and Turkmenistan have good land availability, while land is scarce in Tajikistan and Kyrgyzstan and in some areas of Uzbekistan, such as Khorezm, the Fergana valley and Samarkand provinces.

This situation, plus water scarcity, causes friction between the countries, provinces and tribes. The significance of large-scale development of desert areas during the Soviet period, such as Golodnaya steppe, Karshi steppe, areas along the Kara Kum canal, Asht and Lylak systems, was they allowed the resettlement of hundreds of thousands of people from more populated areas. Such enormous undertakings are no longer a viable option for these post-Soviet, independent and economically weak countries. Thus decision should be based only on the improvement of available resources and not on major new developments (CAWaterInfo, 2011).

Irrigation plays an important role in the economies of Central Asia. While some areas have been irrigated for centuries, central planning created many irrigation and drainage schemes in the 1950s–1980s. In the 1960s, Soviet policy assigned Central Asia the role of supplier of raw material, notably cotton. Irrigation was necessary because of the mainly arid climate in the lower reaches of the Amu and Syr Darya basins. The development of irrigation in the Soviet area of the Aral Sea basin was spectacular: from about 4.5 million ha in 1960 to almost 7 million ha in 1980. Huge schemes were constructed to irrigate desert or steppes and hundreds of thousands of people moved to the areas to work in agriculture. From 1970 to 1989 the irrigated area expanded by 150 percent in the Amu Darya basin and 130 percent in the Syr Darya basin (World Bank, 2003).

Some 32.6 million ha are considered suitable for irrigation in the Aral Sea basin. Currently, the total area equipped for irrigation is around 9.76 million ha (Table 4). The area equipped for irrigation in the Amu Darya basin is an estimated 6 million ha of which 1.3 million ha in northern Afghanistan, 0.1 million ha in Kyrgyzstan, 0.5 million ha in Tajikistan, 1.8 million ha in Turkmenistan and 2.3 million ha in Uzbekistan (Sokolov, 2009; Horsman, 2008; Rout, 2008).

TABLE 4
Irrigation in the Aral Sea basin (Adapted from: Sokolov, 2009; Horsman, 2008; Rout, 2008)

Country	Area equipped for irrigation (AEI)	As % of total	Area actually irrigated (AAI)	AAI as % of AEI
	(million ha)	(%)	(million ha)	(%)
Afghanistan	1.30	13	0.77	59
Kazakhstan	1.30	13	0.83	64
Kyrgyzstan	0.42	4	0.42	100
Tajikistan	0.74	8	0.67	91
Turkmenistan	1.80	19	1.80	100
Uzbekistan	4.20	43	3.70	88
Aral Sea basin	**9.76**	**100**	**8.19**	**84**

More than 90 percent of the Aral Sea basin's crops are produced on irrigated land (Horsman, 2008). Currently, rainfed land does not play a significant role in total agricultural production in the Aral Sea basin, with the exception of extensive (semi-nomadic) livestock husbandry (cattle and sheep). Nonetheless, increasing the productivity of non-irrigated land is an important goal. Some crops (e.g. cereals), which are grown increasingly in irrigated areas, could be moved to non-irrigated areas thus substantially reducing the volume of irrigation water withdrawn in the basin (CAWaterInfo, 2011).

Since independence, the irrigated land area has not changed significantly in Central Asian countries, with the exception of Turkmenistan where the area of irrigated land during 1995–1996 increased by about 400 000 ha. However, there have been major changes in cropping patterns. Cotton is still one of the most important crops, although between 1990 and 1998 its share of irrigated agriculture decreased from 45 to 25 percent. In the same period, the area under cereals (wheat, rice, maize and others) increased from 12 to 77 percent. Wheat became the dominant crop in the region, which covers about 28 percent of total irrigated area. Fodder crops in 1998 occupied less than 20 percent of the total irrigated area, compared to 27 percent in 1990, which is highly undesirable from the viewpoint of maintaining soil fertility and crop rotation (CAWaterInfo, 2011).

Large-scale irrigated farming in the Aral Sea Basin is based on a well-developed system of irrigation and drainage facilities. By the end of 1998, the overall length of main and inter-farm irrigation networks in the basin was 47 750 km and on-farm irrigation networks totalled 268 500 km. Irrigation in Central Asia, and particularly in Uzbekistan, relies on a system of pumps and canals that is among the most complex in the world. Since 1990, on-farm irrigation networks have deteriorated as a result of the poor financial situation of both state-owned and privatized farms, which are unable to reconstruct on-farm networks or maintain them in a satisfactory condition (CAWaterInfo, 2011).

In 1960, total water withdrawal in the Aral Sea basin was an estimated 64.7 km^3. In 2006, it was an estimated 107 km^3 of which irrigation withdrawal accounted for 96 km^3, or 90 percent of the total (Sokolov, 2009). Most of the Amu Darya water is withdrawn by Turkmenistan and Uzbekistan along the section of their common border (Stanchin and Lerman, 2006). Uzbekistan accounts for approximately 56 km^3 (50 km^3 in agriculture) and Tajikistan for 11 km^3 (10 km^3 in agriculture).

Withdrawal of water per irrigated hectare in the Aral Sea Basin is high, in the order of 11 000–14 000 m^3/ha or even more (World Bank, 2003).

During the Soviet period groundwater resources were not widely used for irrigated agriculture in the Central Asian Republics. This is because farmers received sufficient surface water, and had a reliable water supply and irrigation infrastructure. During this period groundwater resources were used primarily for the livestock sector and drinking water supply in both urban and rural areas. The Aral Sea basin countries began useing groundwater during the drought years (1998–2001) to sustain vital agricultural production. Groundwater is of relatively good quality and quantity and provides an alternative to highly salinized surface water.

Afghanistan has traditionally relied upon surface water and groundwater springs and karezes (constructed underground channels) for irrigated agriculture and the share of groundwater irrigation of the cultivated area is around 18 percent. During recent drought years in the Aral Sea basin, the use of deeper groundwater, abstracted from dug wells and boreholes increased rapidly. Private farmers drilled many new wells and boreholes and, in some areas, groundwater abstraction rates are already exceeding, or will soon exceed, sustainable groundwater resources (Rakhmatullaev et al., 2009). Total groundwater extraction in the Aral Sea basin is around 10 km^3 (CAWaterInfo, 2011).

The largest and most important artificial waterway in Turkmenistan is the Kara Kum canal. This canal was constructed in the 1950s and is the longest canal in the world with 1 300 km. Canal capacity is an estimated 630 m^3/s. The canal's inlet on the Amu Darya is just after the river enters Turkmenistan from Uzbekistan. The Kara Kum canal pools the Amu Darya, Murghab and Tedzhen rivers into an integrated water management system. It supplies water to the densely populated south of the country and irrigates more than 1.2 million ha. The canal brings water to Ashgabat and to the oases in the south. Each year it takes 10–12 km^3 from the Amu Darya (Orlovsky and Orlovsky, after 2002).

During the Soviet period, water allocation and irrigation system infrastructure were well maintained and operated, with massive funding coming from the central government. Since the Central Asian countries gained independence, the situation changed dramatically, politically, institutionally as well as technically. The political transition from a planned economy to a market economy introduced 'new' concepts such as land tenure, water rights and different kinds of ownership. The institutional changes are described as a transition from former state collective farms – kholkhoz and sovkhoz – into smaller private farms. Many farmers, however, do not have the capacity to pump and irrigate land on an individual basis (Rakhmatullaev et al., 2009).

Salinization and drainage

Climatic and hydro-geological conditions make the soil in the Aral Sea basin particularly vulnerable to salinization. Some land, especially in the inter-mountain valleys, is initially salt affected as a result of the arid climate. The process of salt accumulation is intensified under the influence of pressure from

deep saline artesian water and the following two factors: (a) additional infiltration of irrigation water to the drainage network, (b) deterioration of downstream water quality. This is the result of natural evaporation processes, the use of overly saline irrigation water as well as naturally poor drainage conditions. The intensity of irrigation in Central Asia requires artificial drainage to control waterlogging and salinization. In 1994, about 40 percent of irrigated land in the basin was saline and groundwater salt content in the lower reaches of the river basins varied between 1 and 30 g/litre. Currently, about 5 million ha have drainage systems, of which about 60 percent is surface drainage, 26 percent subsurface, and 14 percent vertical drainage (tubewells). Uzbekistan has the largest area of artificially drained land in Central Asia.

Several innovations have been made to drainage design to address seepage from irrigation canals and upstream irrigation, percolation from excess irrigation water, groundwater fluxes to the root zone and the accompanying salts moving into the crop root zone. Deeper subsurface drainage depths are considered essential to control waterlogging and salinity. Significant investments were made in drainage in the region until the 1990s. However, with the demise of the Union of Soviet Socialist Republics (USSR), and the deterioration of economic conditions in Central Asia, investment in drainage declined. Drainage systems are no longer properly maintained and the areas suffering from salinization and waterlogging have been increasing (Dukhovny et al., 2007).

Dams and hydropower

More than 80 water reservoirs were constructed in the Aral Sea basin, each with a capacity of over 10 million m^3. In order to modify natural river flow patterns to those needed for water supply, reservoirs were constructed either on rivers (off-stream and river-channel reservoirs) or on main canals (compensation reservoirs) (CAWaterInfo, 2011).

There are more than 45 hydropower plants in the Aral Sea basin, the total capacity of which exceeds 34.5 GW, ranging from 50 to 2 700 MW. The largest hydropower plants are Nurek in Tajikistan on Vakhsh river, with a capacity of 2 700 MW, and Toktogul in Kyrgyzstan on Naryn river, with a capacity of 1 200 MW. Hydropower makes up 27.3 percent of average energy consumption in the Aral Sea basin. Potentially, the region can meet more than 71 percent of its energy requirements from hydropower (CAWaterInfo, 2011).

Afghanistan has no dams in the Aral Sea basin, although the Salma Dam for hydroelectricity is under construction on the Hari Rod river. Originally constructed in 1976, it was damaged early during the civil war. In 2006, India committed to funding the completion of the Salma dam. On completion the hydroelectric plant should produce 42 MW in addition to providing irrigation to 75 000 ha, including stabilization of existing irrigation on 35 000 ha and development of irrigation facilities on an additional 40 000 ha.

In Kazakhstan, the Chardarya dam (5.2 km^3) is the only dam on the Syr Darya, located at the border with Uzbekistan and connected to hydroelectric power stations.

In Kyrgyzstan there are nine reservoirs in the Syr Darya basin, with a total capacity of 22.3 km^3. The Toktogul dam, with a reservoir capacity of 19.5 km^3, on the Naryn river, a northern tributary of the Syr Darya. The dam is multipurpose used for irrigation, hydropower production and flood protection/regulation. However, because it is located near the border with Uzbekistan, it does not play an important role in the irrigation of areas within Kyrgyzstan. In 1985, gross theoretical annual hydropower potential in Kyrgyzstan was an estimated 162 500 GWh and economically feasible potential about 55 000 GWh. The installed capacity of hydropower is about 3 GW, a number of hydropower plants are part of the Naryn-Syr Darya cascade, which are controlled by the Toktogul dam. Hydropower plays a key role in Kyrgyzstan and is the country's main source of energy (about 90 percent of electricity generation in 1995), given its limited gas, oil and coal resources.

In 2010, there were 17 dams in Tajikistan: four in the Syr Darya basin and 13 in the Amu Darya basin of which eight on Vakhsh river, two on Panj river and three on the Kofarnihon river. Their total reservoir capacity is about 29.5 km^3, including the Rogun reservoir on the Vakhsh river (13.3 km^3), which is under construction with completion of its first phase in 2012.

The largest reservoirs are: the Nurek on the Vakhsh river (10.5 km^3), the Kayrakkum on the Syr Darya (4.16 km^3), the Farkhad on the Syr Darya (350 million m^3), the Boygozi on the Vakhsh river (125 million m^3), the Kattasoy on the Kattasoy river (55 million m^3), the Muminabad on the Obi Surkh river (31 million m^3), the Dahanasoy on the Dahanasoy river (28 million m^3) and the Sangtuda 1 on the Vakhsh river (25 million m^3). The Sangtuda 2 reservoir (5 million m^3) on the Vakhsh river was inaugurated in 2011.

The Nurek headwork incorporates a unique rock-fill dam with a central core, 310 m high, there is a power plant with a capacity of 3 000 MW. Nurek and Kayrakkum reservoirs reserve water to irrigate Uzbekistan, Turkmenistan and Kazakstan. In 1999, Tajikistan ranked third in the world for hydropower development, after the United States and the Russian Federation. In 1994, total installed capacity was about 4 GWh, generating about 98 percent of the country's electricity.

In Turkmenistan, total dam capacity accounted for about 6.22 km^3 in 2004. All reservoirs were designed and constructed mainly for irrigation purposes, and are affected by heavy siltation. There are five dams with a capacity of more than 0.5 km^3: Zeid on the Kara Kum canal (2.20 km^3), Dostluk on the Tedzhen river (1.25 km^3), Oguzkhan on the Kara Kum canal (0.88 km^3), Sary-Yazy on the Murghab river (0.66 km^3) and Kopetdag on the Kara Kum canal (0.55 km^3). The Dostluk dam, on the border between the Islamic Republic of Iran and Turkmenistan, is designed for flood control, hydropower generation and flow regulation. In 1993, the gross hydropower potential was an estimated 5.8 GWh, while total installed capacity was about 0.7 GWh. The contribution of hydropower to general energy consumption in Turkmenistan is only about 1 percent.

Most of the large dams in the Aral Sea basin are in Uzbekistan. In the Syr Darya basin, the largest reservoirs are the Charvak reservoir, one of the largest hydropower plants in Central Asia is located on the Chirchiq river, which has a capacity of 1.99 km^3 and 600 MW, and the Andijan reservoir on the Karadarya river in the Fergana valley with a capacity of 1.90 km3. In the Amu Darya basin, the largest reservoir is the Tuaymuyun, in Khorezm vilayat, with a storage capacity of 7.8 km^3, comprised of four separate reservoirs. In the future it is expected that one reservoir in this system (Kaparas) will be used to provide drinking water to Karakalpakstan. This area is experiencing severe environmental problems as a result of the shrinking of the Aral Sea. In Uzbekistan, total installed capacity in 1993 was 1.7 GW, which provided about 12 percent of the country's electricity.

Table 5 shows the existing major dams, larger than 0.1 km^3, with details on height and capacity, where information was available.

TABLE 5
List of major dams (> 0.1 km³) in the Aral Sea river basin

Country	Name	Nearest city	River (Major basin)	Year	Height (m)	Capacity (million m³)	Main use *
Afghanistan	-	-	-	-	-	-	-
Kazakhstan	Chardarya	Chardarya	Syr Darya (SD)	1968	27	5 200	I,H,W,F
Kyrgyzstan	Toktogul	Tash Kumur	Naryn (SD)	1974	215	19 500	I, H
	Kurpsay	Tash Kumur	Naryn (SD)	1981	110	370	I, H
	Papan	Osh	Ak-Bura (SD)	1981	120	260	I, H
Tajikistan	Rogun**	Rogun	Vakhsh (AD)	2012	335	13 300	I,H,F
	Nurek	Nurek	Vakhsh (AD)	1980	300	10 500	I,H,W,F
	Kayrakkum	Khujand	Syr Darya (SD)	1959	32	4 160	I,H
	Farkhad***	Khujand	Syr Darya (SD)	1948	24	350	I,H,W,F
	Boygozi	Nurek	Vakhsh (AD)	1989	54	125	I,F,H
Turkmenistan	Zeid	Turkmenabat	Kara Kum Canal (AD)	1986	12	2 200	I,W
	Dostluk	Saragt	Tedzhen (AD)	2004	n.a.	1 250	I,H,W,F
	Oguzkhan	Mary	Kara Kum Canal (AD)	1975	n.a.	875	I,W
	Sary-Yazy	Tagtabazar	Murghab (AD)	1984	25.5	660	I,W,F
	Kopetdag	Geoktepe	Kara Kum Canal (AD)	1987	n.a.	550	I,W
	Tedzhen-1	Tedzhen	Tedzhen (Tejen) (AD)	1950	n.a.	190	I,W,F
	Tedzhen-2	Tedzhen	Tedzhen (Tejen) (AD)	1960	20.5	184	I,W,F
	Yolotan	Yolotan	Murghab (AD)	1910	n.a.	120	I,W,F
Uzbekistan	Tuaymuyun	Pitnak	Amu Darya (AD)	n.a.	n.a.	7 800	n.a.
	Charvak	Tashkent	Chirchiq (SD)	1977	168	1 990	I,H
	Andijan	Andijan	Karadarya (SD)	1980	121	1 900	I
	Pachkamar	n.a.	Guzar (AD)	1961	71	1 525	I
	Talimarjan	Jangi-Nishon	Karshi canal (AD)	1985	635	1 525	I
	Tudakul	Navoji	Tudakulskaya natural depression (AD)	1983	12	1 200	I
	Kattakurgan	n.a.	Zeravshan (AD)	1953	31	900	I
	Yuzhnosurkhan	Shurchi	Surkhandarya (AD)	1967	30	800	I
	Chimkurgan	Chirakchi	Kashkadarya (AD)	1963	33	500	I
	Tupalang	Shargun	Tupalang (AD)	2002	180	500	I
	Shorkul	Navoji	Zeravshan (AD)	1984	15	394	I
	Farkhad***	n.a.	Syr Darya (SD)	1948	24	350	I,H,W,F
	Kuyumazar	Navoji	Zeravshan (AD)	1958	24	310	I
	Tashkent	n.a.	Chirchiq (SD)		37	250	I
	Karkidon	Kuba	Isfayramsay along the Kuvasay channel (SD)	1967	70	218	I
	Akhangaran	Angren	Akhangaran (SD)	1989	100	198	I
	Gissar	n.a.	Aksu (AD)	1990	139	170	I
	Kasansai	n.a.	Kasansai (SD)	1968	64	165	I
	Uchkyzyl	n.a.	Zang canal, Termiz canal, Surkhandarya river (AD)	1957	12	160	I
	Aktepin	n.a.	Surkhandarya (AD)	n.a.	14	120	I
	Akdarin	n.a.	Akdarya (AD)	n.a.	20	112	I
	Jizzakh	Jizzakh	Gully of Djailmasay (SD)	1973	20	100	I

n.a.: Information not available; SD: Syr Darya major basin; AD: Amu Darya major basin
** I = irrigation; H = Hydropower, W = Water Supply; F = Flood protection*
*** Under construction at the time of writing, 1st phase is expected to be finished in 2012*
**** The Farkhad dam is shared by Tajikistan and Uzbekistan*

ENVIRONMENT, WATER QUALITY AND HEALTH

Irrigation water withdrawal from both the Syr Darya and the Amu Darya continuously reduces the volume of the remaining runoff in the rivers and inflow into the Aral Sea. During the summer months, when demand for irrigation is at its highest, little water reaches the Sea. Diversions for irrigation, and relatively large amounts of water used for leaching and to upstream reservoirs to produce electricity, have reduced important winter flows to the sea (Murray-Rust et al., 2003). The environmental consequences of the huge irrigation development in the Aral Sea basin are numerous:

- Many tributaries have been exploited to such an extent that they no longer contribute directly to the flow of the Amu Darya and Syr Darya. They are: the Zeravshan and Kashkadarya in the Amu Darya basin, and the Arys and Akhangaran in the Syr Darya basin.
- The intensification of irrigated agriculture has led to major waterlogging and salinization.
- At the end of the 1960s water salinity did not exceed 1 g/litre, even in the lower reaches. Currently, it varies from 0.3–0.5 g/litre in the upper reaches to 1.7–2.0 g/litre in the lower

reaches. The highest values occur in March and April in the upper reaches, and around May in the lower (CAWaterInfo, 2012).

- Agriculture in the Aral Sea basin has been practised with a high level of inputs, particularly fertilizers and pesticides, and this has resulted in the deterioration of surface water and groundwater quality. There is also pollution from industrial and municipal waste, especially from metropolitan areas.
- The traditional ecosystem of the two deltas of the Amu Darya and Syr Darya has perished. The marshes and wetlands, which covered some 550 000 ha and were a reservoir of biodiversity until the 1960s, have almost disappeared (only 20 000 ha were left in 1990) giving way to sandy deserts. More than 50 lakes, covering 60 000 ha in the deltas, have dried up.
- The Aral Sea is drying up. Before 1960, the level of the Aral Sea was more or less stable. Its surface area was about 66 000 km^2 and its volume about 1 060 km^3. The combined average discharge of the Amu Darya and Syr Darya to the sea was about 47–50 km^3/year, to which could be added 5–6 km^3/year of groundwater inflow and 5.5–6.5 km^3/year of precipitation over the sea. This total volume of 57.5–62.5 km^3/year compensated for the evaporation over the lake, estimated at about 60 km^3/year. The Aral Sea level was then fluctuating at around 50–53 m asl. The average mineral content of the Aral Sea's water was an estimated 10 g/litre in 1960. Fish capture was about 40 000 tonnes/year and many fish-processing industries were established on the shores of the Aral Sea. Together with fishing, these industries provided employment to many in the local population. In 1965, the Aral Sea received about 50 km^3 of freshwater per year – a value that had fallen to zero by the early 1980s. Consequently, concentrations of salts and minerals began to rise in the shrinking body of water causing severe soil salinity problems, especially in the downstream areas of the region (Murray-Rust et al., 2003). The Sea's level dropped by 17 m, its surface area reduced by half and its volume by three-quarters. By the end of the 1980s, the Aral Sea no longer reached its former shores. Today, the sea is made up of three sections: the Small Sea or Northern Sea in Kazakhstan, the Central Sea, and the Western Sea, which is the deepest, mostly in Uzbekistan. The mineral content of the water has increased four-fold to 40 g/litre, preventing the survival of most fish and wild life in the Aral Sea. Fish capture has become negligible, leaving most people unemployed. All commercial fishing ceased in 1982. Moreover, the former seashore villages and towns are 70 km away from the present shoreline. A secondary effect of the reduction of the Aral Sea's overall size is the rapid exposure of the sea-bed. Strong winds that blow across this part of Asia routinely pick up and deposit tens of thousands of tonnes of exposed soil every year in neighbouring areas and up to a distance of 250 km. This process has not only contributed to the deterioration of air quality for nearby residents, but has reduced crop yields because of the heavily salt-laden particles falling on arable land (Murray-Rust et al., 2003). Salinization is even threatening the cultural heritage of Central Asia: high groundwater levels and salinity are affecting historic monuments in the famous towns of Bukhara and Khiva. The environmental crisis of the Aral Sea basin is a major disaster that has affected the territories of all five riparian Central Asian countries and has resulted in economic losses amounting to US$115 million and social losses of about US$28.8 million annually (Dukhovny and Schutter, 2003).
- With the reduced size of the Aral Sea, its climate modifying function has been lost. The climate around the sea has changed, becoming more continental with shorter, hotter, rainless summers and longer, colder, snowless winters. The growing season has been reduced to an average of 170 days/year causing many farmers to switch from cotton to rice, demanding even more diverted water. Desert storms are frequent, occurring on average more than 90 days a year.
- Communities face appalling health conditions. In Karakalpakstan, drinking water supply is too saline and polluted. The high content of metals such as strontium, zinc and manganese cause diseases and prevent iron absorption, causing anaemia. Between 1985 and 2000, kidney and liver diseases, especially cancer, increased at least 30-fold, arthritic diseases 60-fold and chronic bronchitis 30-fold. The infant mortality rate is one of the highest in the world.

The Amu Darya carries the highest sediment load of all the rivers in Central Asia and one of the highest levels in the world. The sodium adsorption ratio (SAR) normally ranges from 0.5 7 milli-equivalent

(meq)/litre at most gauging stations in the Aral Sea basin. These values indicate that, in general, the water is still suitable for irrigation. During the years since independence from the Soviet Union, strict limitation of water allocation between the countries has been implemented and increasing attention is being paid to ecological aspects. This has led to some improvement of water quality (CAWaterInfo, 2011).

It has been estimated that at least 73 km^3/year of water would have to be discharged to the Aral Sea for a period of at least 20 years in order to recover the 1960 level of 53 m asl. The governments of the riparian countries do not consider this a realistic objective. Other, more feasible options, for the future of the Aral Sea have been envisaged by different parties:

- The stabilization of the Aral Sea at its 1990 level (38 m asl) would require a total inflow of about 35 km^3/year, including the demand for the delta area. However, this would not end the environmental degradation and desertification in the exposed seabed.
- The restoration of the Small Sea, or Northern Sea, to 38–40 m asl would require an inflow of at least 6–8 km^3 in that part of the Aral Sea for the next five years.

The restoration of wetlands in the Amu Darya delta and the conservation of the Western Sea would require an inflow of 11–25 km^3/year, with at least 5–11 km^3 of freshwater. Since 1989, a project has been implemented in Uzbekistan that aims to bring more water to the delta through the collector-drainage network. This water, combined with freshwater, is used to replenish shallow lakes. It has allowed the redevelopment of flora and wildlife in the abandoned areas and stopped the eolian (wind) erosion of the former exposed seabed. Another result of this project has been a higher fish capture, estimated at 5 000 tonne/year in 1993, compared with 2 000 tonne/year in 1988.

TRANSBOUNDARY WATER ISSUES

Afghanistan and the USSR had signed international agreements on the use and quality of Amu Darya transboundary water. In 1946 both nations reached the international water agreement, under which Afghanistan is entitled to use up to 9 km^3 of water from the Panj river. In 1954, the USSR offered US$240 million to Afghanistan and built 100 km of pipeline from Termiz, Uzbekistan. In 1955, the USSR announced further assistance, such as agricultural development, hydroelectric generation and construction of irrigation infrastructure. In 1956, Afghanistan signed a contract accepting Russian supervisors for the construction of water facilities.

At the beginning of 1958, Afghanistan and the USSR reconfirmed and signed the border agreement. The second international agreement on the use and quality of Amu Darya transboundary water was signed in 1958. These agreements founded an international commission to cope with the use and quality of transboundary water resources. After 1963, the relationship between the two nations gradually deteriorated. The Soviet invasion disrupted Afghanistan from 1979 to 1989. After the Soviet withdrawal from Afghanistan in 1989, the USSR collapsed in 1991. Nevertheless, this invasion left profound effects such as ethnic conflicts and the rise of the Taliban (Fuchinoue et al., 2002; Favre and Kamal, 2004).

In the early 1970s, when the Aral Sea started to shrink rapidly, the USSR arrived at an understanding of the need to undertake some reclamation measures. At that time several governmental commissions were established. They concluded that it was necessary to undertake urgent measures, if not to prevent lowering of the Sea level, then to mitigate the negative socio-economic and ecological impacts related to this disaster. Transfer of water from Siberian rivers – from the Ob river to the Amu Darya through a 2 200 km-long canal or from the Volga river to the Aral Sea – in the amount of 18–20 km^3 annually was proposed to improve both water supply and environmental conditions in the Prearalie.

The government of the USSR rejected this proposal in 1986 and submitted a range of alternative measures approved by Resolution No 1110 of 1986. Eventually, two basin water organizations (BWOs), the ‘Amu Darya’ and the ‘Syr Darya’, a special organization ‘Aralvodstroy’, and the coordinator of the

programme, the Consortium 'Aral', were established. During the Soviet period, the sharing of water resources among the five Central Asia republics was based on master plans to develop water resources in the Amu Darya (1987) and Syr Darya (1984) basins. From 1987 to 1990, works related to improving water conservation in the south Prearalie, the right bank drain, and the completion of the Tuaymuyun Reservoir Project were implemented (Dukhovny and Schutter, 2003).

The environmental problems of the Aral Sea, which previously had been an internal issue of the USSR, became internationalized after its demise in 1991. In 1992, the five newly independent countries (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan) signed interstate agreements on water sharing, use, conservation, financing and management. In 1992, the first of these agreements established the Interstate Commission on Water Coordination (ICWC), appointing relevant deputy ministers for water as its members. The ICWC was entrusted with the responsibilities of policy formulation and allocating water to the five countries. The ICWC comprises leaders of water management organizations (deputy ministers for water) of the Central Asian countries and is the highest decision-making body concerned with the regional water supply.

The ICWC annual planning meeting is scheduled towards the end of each calendar year, with high-level government representatives (prime ministers or deputy prime ministers and relevant ministers) of the Central Asian countries participating to discuss preliminary plans and agreements for the following year's water supply. Plans for water supply and mutual agreements regarding all commodities are confirmed at an ICWC meeting in March of the following year. Subsequently, the ICWC conducts working meetings approximately once every three months to discuss the monitoring of water deliveries and any problems with water supply, as well as compliance with agreements (Murray-Rust et al., 2003).

The ICWC operates through four executive bodies: the Amu Darya and the Syr Darya basin valley organizations (BVOs), the Scientific Information Centre (SIC), and the ICWC secretariat. The ICWC secretariat is responsible for facilitating the ICWC meetings, preparation of programmes and projects with the other sister organizations and financial control of the BVOs. The BVOs are responsible for the technical aspects of water allocation, distribution and management at the basin scale and among the countries. The SIC, with its 14 regional branches, is responsible for creating an information base, analysis, and supporting and carrying out programmes to enhance water conservation measures.

The 1992 agreement included the construction of Kambarata 1 reservoir in Kyrgyzstan and Rogun reservoir in Tajikistan.

In 1993, two new organizations emerged: the Interstate Council for the Aral Sea (ICAS) and the International Fund for Saving the Aral Sea (IFAS). The ICAS was created to coordinate implementation of the Aral Sea Basin Programme approved in 1994 and developed by the World Bank, the United Nations Development Programme (UNDP) and the United Nations Environmental Programme (UNEP). The International Fund for Saving the Aral Sea (IFAS) was created to raise and manage its funds. The ICAS subsequently merged with the IFAS in 1997 (Murray-Rust et al., 2003).

The IFAS is headed by one of the presidents of the five countries on a rotation basis. The executive committee of IFAS, comprising the prime ministers of the five states, carries out the functions. In the present context, the institutional framework for water management in the region is a hierarchy with five levels of authority/responsibility. The levels of management responsibility are interstate, state, provincial, district and farm. The interstate level organizations work on two different aspects: IFAS and ICWC handle macro-level water resources, environmental management, funding decisions and political decisions and the BVOs handle technical aspects of water regulation among the countries (Murray-Rust et al., 2003).

Two international freshwater agreements were signed for the Amu Darya by the Central Asian countries. The first agreement was the 'Agreement on joint activities for addressing the Aral Sea and the zone around the Sea crisis, improving the environment, and implementing the social and economic

development of the Aral Sea region', signed in 1993. The second agreement was the 'Resolution of the Heads of States of the Central Asia countries on work of the Economic Commission of ICAS on implementation of the action plan on the improvement of the ecological situation in the Aral Sea Basin for the 3–5 years to come with consideration of social and economic development of the region', signed in 1995 (Fuchinoue et al., 2002). As a result of conflicts, Afghanistan, a critical partner to any future transboundary water management agreement, has so far been unable to participate in any of the discussions or agreements (Favre and Kamal, 2004).

The most acute disagreement in the Syr Darya basin relates to the operation of the Toktogul reservoir (in Kyrgyzstan), which is the largest in the basin and in Central Asia. There is essentially a conflict of interest between Kyrgyzstan, Uzbekistan and Kazakhstan. The two downstream countries of the Syr Darya basin are interested in maintaining storage for summertime irrigation from the Toktogul reservoir, whereas winter energy generation from the reservoir is beneficial to Kyrgyzstan. Much money is required to keep the reservoir in operating condition, but Uzbekistan and Kazakhstan, which are water recipients, pay nothing to maintain the Toktogul reservoir. A similar set of issues may be observed between Tajikistan and Uzbekistan regarding the management of the Kayrakkum reservoir.

Changes in the operation of the Toktogul reservoir have led to negative developments such as insufficient water for irrigation, the population's deteriorating social, economic and living conditions, as well as flooding of populated areas and agricultural land in Uzbekistan and Kazakhstan. Furthermore, the environmental and sanitary situation in the basin has become more acute (UNDP, 2004). An agreement was reached between Kyrgyzstan, Uzbekistan and Kazakhstan in 1996, in which Uzbekistan and Kazakhstan will transfer energy, coal or gas to Kyrgyzstan in the period of power deficit, to compensate for the non-use of water for hydropower in the winter period.

In 1996 a permanent agreement was signed between Turkmenistan and Uzbekistan concerning cooperation on water management issues. This agreement is based on the principles that the Parties:

- recognize the need for the joint use of interstate rivers and other water sources;
- refuse to apply economic and other means of pressure when solving water issues;
- acknowledge the interdependence of water problems and the responsibility of rational water use;
- focus on increasing water inflow to the Aral Sea;
- understand the need to respect mutual interests and settling water-related issues through consensus.

This 1996 Agreement between Turkmenistan and Uzbekistan sets out that:

- land used by Uzbekistan and located within the borders of Turkmenistan is the sole property of Turkmenistan;
- waterworks and water management organizations on the Karshi and Amu-Bukhara canals and Tuyamuin reservoir, located in Turkmenistan, are the property of Uzbekistan;
- land for the Karshi and Amu-Bukhara canals and for the Tuyamuin hydrostation is placed at Uzbekistan's disposal on a chargeable basis;
- Parties will make all necessary attempts to provide normal operation of the interstate waterworks located within their territories;
- companies and organizations, including those dealing with interstate waterworks operations, that are located on the territory of the other Party act according to international rules and the laws of that Party;
- the flow of the Amu Darya at the Kerki gauging station is divided into equal shares (50/50);
- Parties should allocate a portion of their share to the Aral Sea;
- Parties should stop disposal of drainage water to the Amu Darya, independently of the quality of the drainage water;

- Parties jointly implement measures for land reclamation, reconstruction and operation of interstate collectors and irrigation systems, and for construction of water disposal canals;
- Parties will prevent channel deformation and flooding of adjacent areas, caused by operation of the Amu-Bukhara, Karshi, Sovetyab, Dashoguz, Tashsaka, Kylychbay and Shabat-Gazavat water systems;
- Parties will make necessary attempts to prevent flooding of land located along the Daryalyk and Ozerny collectors crossing Turkmenistan, and will bear the cost of the collectors' reconstruction and operation proportional to drainage flow;
- during the driest years limits for reduced water withdrawal are defined by the ICWC, which includes ministries of water economies of all five Central Asian countries.

In 1998, three agreements took place between Kazakhstan, Kyrgyzstan and Uzbekistan: i) on the use of water and energy resources in the Syr Darya basin, ii) on cooperation in the area of environment and rational use of natural resources and iii) on the joint and complex use of water and energy resources of the Naryn Syr Darya cascade reservoirs (OST, 2001).

In 1999, a protocol was adopted for the insertion of amendments and addenda into the agreement between the governments of Kazakhstan, Kyrgyzstan, and Uzbekistan on the use of water and energy resources of the Syr Darya basin (OST, 2001).

In 2002, the Central Asian countries and the Caucasus formed the CACENA Regional Water Partnership under the Global Water Partnership (GWP). Within this framework, state departments, local, regional and professional organizations, scientific and research institutes as well as the private sector and NGOs cooperate in establishing a common understanding of the critical issues threatening water security in the region (SIWI, 2010).

In 2002, the heads of the Central Asian countries developed a 'Programme of concrete action to improve the ecological and economic environment of the Aral Sea Basin for 2003–2010' (UNDP, 2004).

In 2004, experts from Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan produced a regional water and energy strategy within the framework of the United Nations Special Programme for the Economies of Central Asia (UN-SPECA). In collaboration with the European Union Water Initiative (EUWI) and the United Nations Economic Commission for Europe (UNECE) integrated water resources management is being developed in Central Asian countries. In cooperation with Germany and other EU countries, UNECE may play a role in the implementation of the EU Strategy for Central Asia in the water and energy sectors (SIWI, 2010).

The Syr Darya Control and North Aral Sea Phase I Project, which is currently underway, is the first phase of the rehabilitation of the Syr Darya and was identified under the Aral Sea Basin Programme (1994). The objectives of the project are to sustain and increase agriculture (including livestock) and fish production in the Syr Darya basin in Kazakhstan; and to maintain the Northern Aral Sea and enhance ecological/environmental conditions for improved human health and conservation of biodiversity.

The project's components include: building water infrastructure to rehabilitate the Northern Aral Sea, improving hydraulic control of the Syr Darya, rehabilitating the Chardarya dam, restoring aquatic resources, promoting fisheries development, and building institutional capacity. To maintain the integrity of the Northern Aral Sea, the 13 km Kok-Aral dyke was constructed to separate the Northern Aral Sea from the South Aral Sea, completed in August 2005. To increase the flow capacity of the Syr Darya, several additional hydraulic structures were constructed on the river and existing hydraulic structures and the Chardarya dam were rehabilitated.

Successful restoration efforts, initiated by Phase I, provided a catalyst for approval of Phase II in 2009. Phase II will continue efforts to improve water resources management in the Kazakh part of the Syr Darya basin. Based on the results obtained during Phase I, Phase II should further improve irrigation

water supply for agriculture, revitalize the fisheries industry, enhance public health, and ecosystem recovery in the Aral Sea (World Bank, 2008).

Afghanistan has used only about 2 km^3 of the 9 km^3/year of water it is entitled to use under the treaties. Meanwhile, the Panj river has an annual flow of 19 km^3, and Afghanistan's fresh involvement in the process of water use would radically change the Amu Darya flow if the Afghan government decides to develop agriculture in the north (Favre and Kamal, 2004).

Currently, tensions exist between Kyrgyzstan and Uzbekistan in the Fergana valley. The Andijan reservoir, lying in a border area and currently leased to Uzbekistan, increases tensions. Kyrgyzstan claims that it does not receive compensation for the lease while Uzbekistan has been reluctant to enter into negotiations (SIWI, 2010).

Residents of Vorukh in eastern Uzbekistan and Ravot in northern Tajikistan both have access to the Isfara river for most of the year. However, once the growing season begins, farmers from upstream Ravot irrigate their fields and unintentionally cut off access to water for Vorukh. The Community Initiative Group, a council of active citizens from all walks of life, undertook the design and implementation of a project, which required the repair and rehabilitation of three wells, in addition to the construction of a 3.5 km water pipeline. The total cost of the project was approximately US$17 000, with roughly half coming from the community itself. More importantly, this group has stressed the long-term management of this project (USAID, 2012).

Afghanistan is planning to construct dams and facilities on its rivers for flood control, electricity generation and irrigation expansion. Once implemented, such projects would impact the amount of water and timing of peak runoff to the Islamic Republic of Iran, Pakistan, Uzbekistan and Turkmenistan (Khurshedi, 2011). Uzbekistan doesn't agree with the construction of reservoirs in the mountainous area of Tajikistan and Kyrgyzstan. Kyrgyzstan and Tajikistan indicate that the Aral Sea problem is mainly because of inefficient water use for irrigation (<30 percent).

In 2010, the United Nations Secretary-General Ban Ki-moon called the diminishing of the Aral Sea "one of the worst environmental disasters in the world" and asked regional leaders to come together to solve the crisis (Seela, 2010).

Table 6 lists the main historical events in the Aral Sea Basin.

TABLE 6
Chronology of major events in the Aral Sea river basin

Year	Plans/projects/treaties/conflicts	Countries involved	Main aspects
1946	International water agreement	USSR, Afghanistan	Both nations reached the international water agreement, under which Afghanistan is entitled to use up to 9 km^3/year of water from the Panj river.
1954	Pipeline built	USSR, Afghanistan	The USSR offered US$240 million to Afghanistan and built 100 km of pipeline from Termiz, Uzbekistan.
1958	Agreement on the use and quality of Amu Darya	USSR, Afghanistan	The second agreement on the use and quality of Amu Darya transboundary water signed. These agreements founded an international commission to cope with the uses and quality of transboundary water resources.
1970's	Several commissions were established	USSR	When the Aral Sea started rapidly shrinking several governmental commissions were established.
1980's	Establishment of BWOs, Aralvodstroy and the Consortium Aral	USSR	Two basin water organizations (BWOs) 'Amu Darya' and 'Syr Darya', a special organization 'Aralvodstroy', and the coordinator of the programme - the Consortium 'Aral' – were established.
1984	Master plan Syr Darya	USSR	Master plan for the water resources development in the Syr Darya.

TABLE 6 *(continued)*
Chronology of major events in the Aral Sea river basin

Year	Plans/projects/treaties/conflicts	Countries involved	Main aspects
1987	Master plan Amu Darya	USSR	Master plan for the water resources development in the Amu Darya.
1992	Interstate agreements on water	Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan	The five newly independent countries signed interstate agreements on water sharing, use, conservation, financing and management.
1992	Interstate Commission on Water Coordination (ICWC)	Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan	The first of the 1992 agreements established the ICWC, which was entrusted with the responsibilities of policy formulation and allocating water to the five countries.
1993	Interstate Council for the Aral Sea (ICAS) and International Fund for Saving the Aral Sea (IFAS)	Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan	Two new organizations emerged: the Interstate Council for the Aral Sea (ICAS) and the International Fund for Saving the Aral Sea (IFAS).
1993	Agreement on the Aral Sea, Amu Darya and Syr Darya	Kazakhstan; Kyrgyzstan; Tajikistan; Turkmenistan; Uzbekistan	Agreement on joint activities in addressing the Aral Sea and the zone around the Sea crisis, improving the environment, and ensuring the social and economic development of the Aral Sea region.
1994	Aral Sea Basin Programme (ASBP)	Kazakhstan; Kyrgyzstan; Tajikistan; Turkmenistan; Uzbekistan	The Aral Sea Basin Programme was approved in 1994 and developed by the World Bank, UNDP and UNEP. The ICAS was created to coordinate implementation of the Programme.
1995	Resolution on the implementation of the action plan on the improvement of the ecological situation in the Aral Sea Basin	Kazakhstan; Kyrgyzstan, Tajikistan; Turkmenistan; Uzbekistan	Resolution of the heads of states of Central Asia on work of the EC of ICAS on the implementation of the action plan on the improvement of the ecological situation in the Aral Sea Basin for the 3-5 years to come with consideration for social and economic development of the region
1996	Agreement on transfer of energy, coal or gas to compensate the non-use of water for hydropower in the winter period	Kyrgyzstan, Uzbekistan and Kazakhstan	Uzbekistan and Kazakhstan will transfer energy, coal or gas to Kyrgyzstan in the period of power deficit, to compensate for the non-use of water for hydropower in the winter period.
1996	Agreement on water management issues	Turkmenistan and Uzbekistan	A permanent agreement was signed between Turkmenistan and Uzbekistan on cooperation in water management issues.
1997	ICAS merged into IFAS	Kazakhstan; Kyrgyzstan, Tajikistan; Turkmenistan; Uzbekistan	The ICAS merged into the IFAS.
1998	Agreement on the use of water and energy of the Syr Darya Basin	Kazakhstan, Kyrgyzstan, Uzbekistan	Agreement between Kazakhstan, Kyrgyzstan and Uzbekistan on the use of water and energy resources of the Sry Darya Basin.
1998	Agreement on the Naryn Syr Darya cascade reservoirs	Kazakhstan, Kyrgyzstan, Uzbekistan	Agreement between Kazakhstan, Kyrgyzstan and Uzbekistan on joint and complex use of water and energy resources of the Naryn Syr Darya cascade reservoirs.
1998	Agreement on cooperation in environment and rational nature use	Kazakhstan, Kyrgyzstan, Uzbekistan	Agreement between Kazakhstan, Kyrgyzstan and Uzbekistan on cooperation in the area of environment and rational nature use.
1999	Amendments and addenda in agreement on the use of water and energy of the Syr Darya Basin	Kazakhstan, Kyrgyzstan; Tajikistan, Uzbekistan	Protocol on inserting amendments and addenda in the agreement between the governments of Kazakhstan, Kyrgyzstan, and Uzbekistan on the use of water and energy resources of the Syr Darya basin.
2002	Programme of concrete action to improve the ecological and economic environment of the Aral Sea Basin	Kazakhstan; Kyrgyzstan, Tajikistan; Turkmenistan; Uzbekistan	Central Asian states took a decision to develop a 'Programme of concrete action to improve the ecological and economic environment of the Aral Sea basin for 2003–2010'.
2005	Syr Darya Control and North Aral Sea Phase I Project	Kazakhstan; Kyrgyzstan, Tajikistan; Turkmenistan; Uzbekistan	Completion of the first phase of the project.
2009	Syr Darya Control and North Aral Sea Phase II Project	Kazakhstan; Kyrgyzstan, Tajikistan; Turkmenistan; Uzbekistan	Approval of the second phase of the project.

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