The water balance and the solution of water problems in the central Asian region

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Abstract Central Asia (formerly known as Middle Asia and Kazakhstan) includes the republics of the CIS namely: Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan and Turkmenistan and also Afghanistan. Hydrologically, the Central Asian Region (CAR) is identified by the basin of the Aral Sea, which consists of two basins—those of the Syrdarya and the Amudarya rivers. This paper discusses the water resources of the region and their uses, particularly for irrigation and hydropower, the problems that have arisen and some of the solutions.

Key words Aral Sea basin; degradation of the Aral Sea; growing season; hydropower production; irrigated agriculture; transitional economy; USSR; water diversions; water/energy resources

INTRODUCTION

After the Soviet Union collapsed, the Republic of Kazakhstan, the Kyrgyz Republic and the Republics of Tajikistan, Turkmenistan and Uzbekistan in central Asia gained independence. These Central Asian (CA) countries are located in the ecological zone of the Aral Sea basin. The region’s ecosystem is very sensitive to anthropogenic influences, largely due to the arid conditions that exist there. The total area of the Central Asian Region (CAR) is about 3 882 000 km$^2$ with a population of over 53 million.

In the Central Asian Region water is one of the most important factors. It defines the chance of life and the opportunities for development in such an arid zone. The Syrdarya is one of the two great central Asian rivers. Over 20 million people live along its banks. Their existence and development have been provided for by the rivers waters for many hundreds of years.

The Syrdarya basin is part of the basin of the Aral Sea and it occupies 485 500 km$^2$. The length of the Syrdarya is 2337 km and, in terms of the total flow of the river, its water resources on average amount to 40.6 km$^3$ year$^{-1}$.

The Amudarya basin has a total area of 1 017 800 km$^2$ and is also part of the same Aral Sea basin. With a total length of 2574 km and a catchment area of 226 800 km$^2$, the Amudarya is the largest river in the CAR in terms of its water resources, which total 76 km$^3$ year$^{-1}$.

The water resources of the CAR are used mainly for agriculture, especially for irrigation (80–90%). Within the CAR, the land which is irrigated covers an area of $7.95 \times 10^6$ ha. However, due to the low efficiency of most of the distribution systems there are large water losses. As a result, water use in the lower courses of the rivers is much reduced, and in many basins, particularly the smaller ones, the rivers have dried up.
In view of the ecological demands—the level of the safe water input to the Aral Sea is defined as 78 km$^3$—but the water use per capita is twice that anywhere else in the world. In fact, on average, annually 2892 m$^3$ are used per capita, varying between the different countries from 2200 to 4000 m$^3$ per capita. The volume of water used in the Syrdarya basin, 52 km$^3$ year$^{-1}$, exceeds the river’s natural discharge.

WATER RESOURCES OF THE CENTRAL ASIAN REGION

The CAR is characterized by an uneven distribution of water resources. Flow is generated in the high mountains of the south and east where precipitation amounts are large: but in most of the Aral Sea basin to the north and west, evaporation rates are considerable and precipitation is scant. Kirgizstan and Tajikistan are located entirely in the zone of flow formation. This zone, which occupies an area of a little more than 20% of the total, produces about 90% of the region’s surface runoff, the main hydro-potential being focused here. Kazakhstan, Turkmenistan and Uzbekistan are situated in the flow dispersing zone, which is the most suitable for the development of irrigated agriculture due to the relief and the fertile soils.

After 1991, because of the economic recession, infringement of economic interstate communications and the not-always-successful attempts of these new nations to enter the world market system, the opportunity to carry out indemnification for the non-production of energy was reduced. In the absence of other alternatives, the Kyrgyz Republic was compelled to meet its energy needs (first for the domestic sector) from the cascade of the Narynsk hydropower stations. The Toktogul Reservoir was transferred to a power operating mode, when most of the annual volume had already been discharged during the dormant season (up to 8 km$^3$ and more, instead of the previous 3 km$^3$) with a respective reduction in the water released during the growing season.

Since 1995 the mechanism for compensating for deliveries was renewed, when interstate agreements were made for the forthcoming business year, in which the sizes of deliveries of water and power resources from Uzbekistan and Kazakhstan to Kirghyzia were established and the size of vegetative spill water from Toktogul was determined. This allowed for the average annual water content to provide for the needs of irrigated agriculture in the region: but the water spilled in autumn-winter was still within the limits of 7–8 km$^3$. Agreements were made with some delays and they were not always carried out in full, something that was also reflected in the work of the Toktogul hydro unit.

The basic drawback in the practice, which was established after 1995, was that deliveries of water under the agreements made between Kyrgyzstan and the downstream states allowed the needs of the irrigation of the region to be provided for during the growing season, but did not take into account the operation of the Toktogul hydro unit during the autumn–winter. Toktogul was, of course, built to meet the demand for electricity of the Kirghyz Republic. To stop the generation of electricity at Toktogul because of the lack of water would be impossible, but to allow irrigated agriculture to be in crisis during the growing season would also be very difficult. Consequently the situation was in deadlock. To help to find a way out of this situation it required all the volumes of water to be known, together with the mode of spillage from Toktogul in order to compensate Kirghyzia for the retention of the water in the
Table 1 Indicators of macroeconomic development of the central Asian region.

<table>
<thead>
<tr>
<th>Country</th>
<th>Area (thousand km²)</th>
<th>Population, (million people)</th>
<th>Per capita gross inland output by purchasing capacity parity, (thousand dollars/man)</th>
<th>Per capita energy consumption, (tons of conventional fuel/man)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kazakhstan</td>
<td>2636.20</td>
<td>14.95</td>
<td>3.56</td>
<td>3.67</td>
</tr>
<tr>
<td>Kyrgyzstan</td>
<td>198.50</td>
<td>4.90</td>
<td>0.68</td>
<td>0.66</td>
</tr>
<tr>
<td>Tajikistan</td>
<td>143.10</td>
<td>6.20</td>
<td>0.99</td>
<td>0.84</td>
</tr>
<tr>
<td>Turkmenistan</td>
<td>488.00</td>
<td>4.70</td>
<td>1.52</td>
<td>3.30</td>
</tr>
<tr>
<td>Uzbekistan</td>
<td>447.36</td>
<td>24.60</td>
<td>2.26</td>
<td>2.70</td>
</tr>
<tr>
<td>CA</td>
<td>3913.16</td>
<td>55.35</td>
<td>2.22</td>
<td>2.64</td>
</tr>
</tbody>
</table>

Table 2 Surface water resources of the Aral Sea basin.

<table>
<thead>
<tr>
<th>Country</th>
<th>The Amudarya River basin (km³/year⁻¹)</th>
<th>The Syrdarya River basin (km³/year⁻¹)</th>
<th>The Aral Sea basin (km³/year⁻¹) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kazakhstan</td>
<td>—</td>
<td>4.50</td>
<td>4.50</td>
</tr>
<tr>
<td>Kyrgyzstan</td>
<td>1.90</td>
<td>27.4</td>
<td>29.30</td>
</tr>
<tr>
<td>Tajikistan</td>
<td>62.9</td>
<td>1.1</td>
<td>64.00</td>
</tr>
<tr>
<td>Turkmenistan</td>
<td>2.78</td>
<td>—</td>
<td>2.78</td>
</tr>
<tr>
<td>Uzbekistan</td>
<td>4.70</td>
<td>4.14</td>
<td>8.84</td>
</tr>
<tr>
<td>Afghanistan</td>
<td>6.18</td>
<td>—</td>
<td>6.18</td>
</tr>
<tr>
<td>CA</td>
<td>78.46</td>
<td>37.14</td>
<td>115.6</td>
</tr>
</tbody>
</table>

reservoir for use during the growing season. Only with this knowledge was it possible to try to restore and to maintain the role of the Toktogul hydro unit on the Syrdarya.

When the USSR existed, all the central Asian republics were considered as being amongst the industrially developed countries. Today they are countries with transitional economies, at much lower levels, and there are differences between them (Table 1). One of the main resources of the central Asian region is water. Not without reason, the year 2003 was proclaimed the “The International Year of Freshwater” by the UN General Assembly on the initiative of Tajikistan—the country where >50% of all the water resources of the region are generated. The International Forum on water was held in Dushanbe, the capital of Tajikistan, in August 2003.

The total surface water resources of the basin of the Aral Sea is 115.6 km³ year⁻¹ (Table 2). According to estimates, the groundwater resources reach 43.7 km³ year⁻¹, 15.8 km³ year⁻¹ (36.2%) of them being exploited. Moreover, a large quantity of return waters is formed in the Aral Sea basin from the irrigation, 45.8 km³ year⁻¹, a small part of which is used for further irrigation—6.0 km³ year⁻¹, while a greater part runs off in the rivers (23.5 km³ year⁻¹), with some natural reduction (16.3 km³ year⁻¹).

Evaluations of the adequacy of these resources for central Asia are somewhat ambiguous. If we compare them with countries with similar climatic conditions, such as with Israel, we can reach the conclusion that the water resources available today are sufficient if modern methods of water usage are employed (Table 3). With the present conditions of management however, it is an incontestable fact that the available water resources will not meet the demand, especially in dry years. The most well known consequence of this situation is the crisis in the Aral Sea and the shrinkage of its shore line.
Table 3 Specific consumption of water in central Asia and Israel.

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Central Asia</th>
<th>Israel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total specific consumption per capita (m³ year⁻¹)</td>
<td>345</td>
<td>2875</td>
</tr>
<tr>
<td>On irrigation (m³ year⁻¹)</td>
<td>5590</td>
<td>12 887</td>
</tr>
<tr>
<td>The same, taking into account natural precipitation (km³ ha⁻¹)</td>
<td>10 390</td>
<td>14 690</td>
</tr>
</tbody>
</table>

IRRIGATION AND HYDROPOWER PRODUCTION IN CENTRAL ASIA: PROBLEMS AND CONTRADICTIONS

The principal spheres of the use water resources in central Asia today are irrigated agriculture and hydropower production. Irrigation appeared in central Asia in the sixth and seventh centuries BC. Since then, its role has been constantly expanding with the increase of the irrigated areas. By the beginning of the 20th century about \(3.5 \times 10^6\) ha were being irrigated in the region. During the existence of the USSR, rapid development of irrigation took place, especially between 1960 and 1990. By 1990 the total area under irrigation had increased to \(8.8 \times 10^6\) ha, including:

(a) Kazakhstan, up to \(2.8 \times 10^6\) ha
(b) Kyrgyzstan, \(1.1 \times 10^6\) ha
(c) Tajikistan, up to \(0.7 \times 10^6\) ha
(d) Uzbekistan, up to \(4.2 \times 10^6\) ha

A similar sharp rise took place during the Soviet period in power production. In the 1930s, within one generation, hydroelectric engineering was founded—a new technology. The total installed capacity of the region by grew to \(37.8 \times 10^6\) kW, including:

(a) Kazakhstan, \(18.5 \times 10^6\) kW
(b) Kyrgyzstan, \(3.8 \times 10^6\) kW
(c) Tajikistan, \(4.4 \times 10^6\) kW
(d) Uzbekistan, \(11.3 \times 10^6\) kW

At that time the capacity of hydroelectric power stations in the region reached 11 310 000 kW, including:

(a) Kazakhstan, \(2.22 \times 10^6\) kW
(b) Kyrgyzstan, \(2.95 \times 10^6\) kW
(c) Tajikistan, \(4.40 \times 10^6\) kW
(d) Uzbekistan, \(1.74 \times 10^6\) kW

Unfortunately these impressive results brought about some negative consequences. The pace of development disturbed the processes which maintain the ecological equilibrium of the region. This became especially apparent in and around the Aral Sea. As the sea shrank, the desertified area grew, the salinated soils expanded, the quality of water, especially in the lower reaches of rivers, worsened and there were many other adverse effects. By the 1970s the water resources of the Syrdarya River basin were almost completely exhausted. These circumstances created mounting ecological problems for the region of global proportions and made the Aral Sea into an ecological disaster.
One of the reasons of this situation was that the development programmes, for both irrigation and power production, laid down at the time of the USSR were not accomplished. For economic and scientific reasons, the project for transferring flow from the Siberian rivers, which could have solved all the problems resulting from the development of irrigation and which would have saved the Aral Sea even under the existing conditions of management, was completely stopped.

Only a start was made to the programme of hydroelectric development in the region. Construction of new hydroelectric power stations in Tajikistan with total capacity of \(7.7 \times 10^6\) KW and putting them into operation was provided for in the plan: “Concept of the USSR power engineering development for the period 1991–2005”. The problems became even more acute after the collapse of the USSR and the formation of the new independent states. One of these problems is connected with the contradiction between irrigation and hydroelectric engineering.

Irrigated agriculture demands the maximum use of water during the growing season, from April to October. On the other hand, hydroelectric energy is concerned with the use of river water in winter, the coldest period of the year, the period when rivers contain little water, from October to April. For irrigation the reservoirs need to be filled in winter and used in summer, but for energy it is the opposite, the reservoirs should be filled in summer and used in winter. It is impossible to combine both interests in one reservoir. This is the situation faced in the basin of the Aral Sea today. The number of reservoirs is quite limited in the zone where runoff is generated, where the principal regulation of the flow is carried out. There is only one such reservoir in Tajikistan in the upper reaches of the Amudarya River, namely the Nurek Reservoir. In the Syrdarya basin there are three of these reservoirs: the Toktogul Reservoir in Kyrgyzstan, the Kayrakkum Reservoir in Tajikistan and the Andijan Reservoir in Uzbekistan. But of the last three, the Toktogul Reservoir is the only one which can carry out long-term regulation of the flow. In addition these reservoirs are located in different states, so that the co-ordination of their operation is a problem in itself.

The hydrological contrasts between irrigation and hydropower production are complicated by the fact that the upstream countries—Kyrgyzstan and Tajikistan, are interested in water for energy production, while the downstream countries—Kazakhstan, Turkmenistan and Uzbekistan, want water for irrigation. This extremely complex situation is made even worse in the Syrdarya River basin, where all the water resources were already exhausted by the 1980s.

The peculiarity of today’s water/energy situation in the basin of the Aral Sea, is that it did not appear initially, but is a consequence of the cardinal changes in the geopolitical and economic conditions of the region since the demise of the USSR.

When the water-based economic complex of central Asia was being established under the Government of the USSR, all the questions concerning the uses of water resources were unambiguously settled within a common and systemic approach, though to a considerable extent an administrative-command one:

(a) A methodology was established that functioned in a complex manner for financing the different hydro units at the expense of the different branches with shares in proportions determined by economic calculations.

(b) Common and individual criteria of effectiveness were worked out and priorities were identified. In Middle Asia priority was given to cotton growing.
(c) And finally, the necessary mechanisms for compensation that functioned at that time were worked out. In particular the electricity losses of the separate union republics, connected with the work of hydro units during the irrigation regime, were provided by intergovernmental off-seasonal electrical energy transmissions between HPS and TPS and their work regimes were organized correspondingly.

Today, after the collapse of the USSR and the formation of the new independent states, such a methodology would not function. All the states concerned try to advance their own national interests. Neither international law, nor national laws and existing precedents provide any terms of reference on the use of their reservoirs by states when they are located on transboundary rivers. At best the code of conduct towards neighbouring countries can be formulated in the following way:

A sovereign state possesses all the rights of absolute establishment corresponding to its national interests on any river flow regulation regimes by the reservoirs belonging to it and located on its territory.

In cases where these regimes damage the interests of other states in the basin, a state-owner must with agreement change its work regimes in favour of the other states concerned with provisions from its side for proper compensation.

Taking into consideration the complexity and length of such negotiations during the creation of the newly independent states, special agreements were signed between the central Asian republics providing for the preservation of the mutual relations which had existed between them during the existence of the USSR in the field of water-energy resources:

(a) Agreement between the Republic of Kazakhstan, the Republic of Kyrgyzstan, the Republic of Uzbekistan and Turkmenistan on cooperation in the field of the joint management of intergovernmental sources water resources use and protection. Alma-Ata, 18 February 1992.


The first of these runs as follows:

"Recognizing commonality and unanimity of the region's water resources the Sides possess equal rights on use and responsibility for provision of their efficient use and protection".

The second declares:

"We agree with the fact that central Asian states recognize the earlier signed and acting agreements, treaties and other acts corresponding to the norm regulating mutual relations between them on water resources in the Aral Sea basin and take them for their unswerving execution".

Signing these agreements took place during that complicated period when the new states were being formed, with the aim of smoothly reforming the system, avoiding anarchy, but providing for success in decision-making. At the same time they bore a political character without touching upon the economic substance of the question. Therefore such a system of relationships could not remain long without change. And the need arose for making such changes at the same time that they were being signed:

In it is noted:

"The states-participants recognize as common objectives: regulating the system and improving the discipline of water use in the basin, working out corresponding intergovernmental legal and normative acts providing for common use for the region of the principles of recovering losses and damages".

This present-day scheme of relationships and agreements between the central Asian republics began to be created in 1994. On 17 March 1998 it was officially registered by the signing of the Bishkek "Agreement on the use of the Syrdarya River basin water and energy resources between the Government of the Republic of Kazakhstan, the Government of the Republic of Kyrgyzstan and the Government of the Republic of Uzbekistan", which was joined by the Republic of Tajikistan on 17 June 1999.

A common system for relationships between the sides regarding services and compensations for the flow regulation of the Syrdarya River was determined according to this agreement. It provided that:

Extra electric energy generated in excess of the needs of the Republic of Kyrgyzstan and the Republic of Tajikistan by the cascade of Naryn-Syrdarya hydro-electric power stations connected with the regime of removals of water into vegetation and a long-term flowing regulation in the Toktogul and the Kayrakkum reservoirs is given in equal parts to the Republic of Kazakhstan and the Republic of Uzbekistan. Its compensation is according to concordance or as pecuniary compensation to the Republic of Kyrgyzstan and the Republic of Tajikistan to make necessary annual and long-term reserves of water in reservoirs for irrigative needs. While performing reciprocal settlement of accounts a common tariff policy on all types of energy resources and their transportation must be provided.

The Bishkek Agreement was signed on 17 March 1998 and can be considered as an absolute success. However, unfortunately its practical implementation leaves much to be desired.

Kyrgyzstan does not meet the requirements for the regulation of flow for irrigation. In the majority of cases it gives priority to its national energy needs, using water in winter and storing it in summer.

As can be seen in Figs 1 and 2 the Toktogul Reservoir has not been operated to regulate the seasonal flow to store water for irrigation. The reservoir is filled during the growing period and this water is used in the winter, i.e. it is operated purely for energy production. There is also no long-term regulation of flow by the Toktogul Reservoir. As a consequence from 1994 to 2002 the reservoir was nearly completely drawn down, although according to Table 4, flow of the river during all this period was above the average.

The increased winter drawdown of the Toktogul Reservoir is the reason why an unfavorable situation was created in the middle reaches of the Syrdarya River, i.e. in the lower hydro unit of Chardarya. The river channel does not have the capacity to carry all the flow, flooding took place in Kzyl-Orda and water flowed into the Arnasay
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Fig. 1 Toktogul Reservoir. Diagram of seasonal filling and use.

Fig. 2 Regime of Toktogul Reservoir work.

Table 4 Inflow to the Toktogul Reservoir.

<table>
<thead>
<tr>
<th>Inflow (km$^3$ year$^{-1}$)</th>
<th>Year</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Aver.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual</td>
<td>15.24</td>
<td>10.9</td>
<td>13.7</td>
<td>10.8</td>
<td>14.5</td>
<td>14.5</td>
<td>12.6</td>
<td>11.4</td>
</tr>
<tr>
<td>Average long-term</td>
<td>11.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
depression, to aggravate the problem of the Aral Sea. Constrictions in the riverbed of the Syrdarya in Kazakhstan violate the norms and regulations of CNAR, this only corroborates the thesis that ecological problems in the water energy complex are to a considerable extent connected with administrative and organizational decisions.

Until recently Tajikistan improved the situation to some extent by changing the regulation of river flow through the Kayrakkum Reservoir in the interests of the irrigation in Kazakhstan and Uzbekistan. This is shown in Figs 3 and 4. But first, in contrast to the Toktogul Reservoir, the Kayrakkum Reservoir can only regulate seasonal, but not long-term flow. Without sufficient compensation for these services, Tajikistan made changes to the regulation regime to display good will. However, this cannot be the basis of operation for a lengthy period under today’s market forces.

**Fig. 3** Kayrakkum Reservoir. Diagram of a seasonal filling and work.

**Fig. 4** Regime of Kayrakkum Reservoir work.
The sustainable use of the water and energy resources of the basin seems very difficult to achieve under these conditions. The energy regime of Kyrgyzstan annually requires a volume of water greater than the flow into the Toktogul Reservoir. As a consequence Kyrgyzstan pointed out in an official statement that the irrigation needs of Kazakhstan and Uzbekistan will not be met in a dry year when there will be a shortfall of 1.5 billion m$^3$. At best this will lead to a reduction of 150,000 ha in the irrigated area, a serious problem for the region.

In actual fact the situation is more disquieting. According to an announcement made by Kyrgyzstan, by maintaining this regime the Toktogul Reservoir could be completely drained down to its dead volume in two consecutive dry years. The water deficit in the growing season would be 3–5 billion m$^3$. This would be an ecological disaster. At the same time Kyrgyzstan would incur severe losses while using the long-term storage in the Toktogul Reservoir. The point is that during dry years there will be no water left in the country itself. The regime of the use of the Reservoir is not in itself optimal from the energy point of view, as the hydroelectric power station works inefficiently. The losses are very considerable. This is shown in Table 5.

Working with a half-full reservoir with a volume of 11–12 km$^3$ of direct losses from Toktogul HPS, electricity generation in the years 1994–2001 was on average $950 \times 10^6$ KW h$^{-1}$ a year, i.e. 20% of the highest possible level of HPS generation.

However, despite Kyrgyzstan not fulfilling its obligations, both in the long term and seasonally Uzbekistan and Kazakhstan made full payments for the services provided according to the Agreement. Uzbekistan also made payments to Tajikistan for the regulation of seasonal flows by the Kayrakkum Reservoir, i.e. it pays twice for the same service.

Payment to Kyrgyzstan for its services is carried out according to the following protocol. In addition to the supply of 2.2 billion m$^3$ of water during the growing season Kyrgyzstan also supplies Uzbekistan and Kazakhstan with 2.2 billion KW h$^{-1}$ of electricity annually. The energy is distributed in equal parts between the two countries. By way of compensation, Uzbekistan:

(a) supplies Kyrgyzstan with $600 \times 10^6$ KW h$^{-1}$ of natural gas that is equivalent to 3.22 billion KW h$^{-1}$ of electrical energy;
(b) supplies Kyrgyzstan with 20 t of turbine oil and 500 t of transformer oil. At the price of $400$ per tonne and $300$ per tonne, respectively, their total cost is equal to $230,000$ that is equivalent to $11.5 \times 10^6$ KW h$^{-1}$ of electric energy at a price of 2 cents per KW h$^{-1}$;
(c) delivers $500,000$ worth of rail services equivalent to $25 \times 10^6$ KW h$^{-1}$ of electricity at a price of 2 cents per KW h$^{-1}$. Thus in total Uzbekistan returns to Kyrgyzstan the equivalent of 3.25 billion KW h$^{-1}$ of electrical energy.

| Table 5 | Technical-economic indicators of Toktogul HPS according to the reservoir volume. |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Reservoir vol. (km$^3$) | 19.5 | 17.0 | 15.0 | 13.0 | 11.0 | 9.0 | 7.0 | 5.0 |
| HPS pressure (m) | 174 | 164 | 157 | 149 | 140 | 130 | 120 | 108 |
| Use of water on 1 KW h$^{-1}$ (m$^3$) | 2.29 | 2.42 | 2.57 | 2.68 | 2.87 | 3.20 | 3.46 | 4.16 |
| Undergeneration ($\times 10^6$ KW h$^{-1}$) | – | 268 | 522 | 710 | 975 | 1377 | 1628 | 2164 |
By way of compensation, Kazakhstan supplies Kyrgyzstan:

- 566.7 t of Karaganda coal that is equivalent to 2.97 billion KW h⁻¹ of electricity, even at the low calorific value of coal of 4500 kilocalories kg⁻¹ assuming a 60% coefficient of efficiency.

As a result, Kyrgyzstan is in profit to the tune of 4.02 billion KW h⁻¹ of electricity (3.25 + 2.97 - 2.2). This quantity of electricity is considerable for Kyrgyzstan. It makes up one third of the total electrical output in the republic and only a little less than the annual total generation by the biggest installation, namely the Toktogul HPS. At the same time, together with the water supplied during the growing season, Tajikistan provides Uzbekistan with 300 × 10⁶ KW h⁻¹ of electricity annually. By way of compensation the republic receives 200 × 10⁶ KW h⁻¹ of electricity from Uzbekistan. According to the agreement during the 3 months when Tajikistan receives electricity from Uzbekistan, it does not present payment to the latter for this service. Under the usual conditions such a payment is about $250 000 per month which gives a total of $750 000 for 3 months. At the rate of 2 cents per KW h⁻¹ this is equivalent to 337 million KW h⁻¹ of electricity. In other words Tajikistan gets no compensation from Kazakhstan at all. So in return for 200 × 10⁶ KW h⁻¹ of electricity from Uzbekistan, Tajikistan gives Uzbekistan 337 × 10⁶ KW h⁻¹, i.e. unlike Kyrgyzstan, Tajikistan works at a loss.

As a consequence of these defects all the participants of the Bishkek agreement signed in 17 March 1998 suffer appreciable losses:

(a) Uzbekistan and Kazakhstan do not have an assured supply of water for irrigation, in the absence of long-term regulation of the flow of the Syrdarya River by the Toktogul Reservoir. At the same time, Uzbekistan pays twice for the same service for seasonal flow regulation—both to Kyrgyzstan and Tajikistan.

(b) Despite not carrying out long-term flow regulation, Kyrgyzstan has, nevertheless, to work the Toktogul Reservoir on account of the winter electricity deficit, as a result of which the Toktogul HPS always works on reduced heads of water. The annual loss of energy generation is about 1 billion KW h⁻¹, and this is a direct loss.

(c) Tajikistan receives electricity from Uzbekistan by way of compensation for carrying out the seasonal regulation of flow, a compensation which is 1.5 times less than the quantity that it supplies. Kazakhstan does not pay Tajikistan for the service it is provided with.

The main reason for this complex situation is the absence of a clearly developed and coordinated mechanism for the calculation of the economic costs of these services and the different amounts of compensation for the regulation of flow. The solution of this problem is a top-priority matter for the republics of the basin of the Aral Sea today.

POSSIBLE REASONABLE SOLUTIONS FOR IMPROVING THE SITUATION

In principle, there are a number of different means offering possible solutions. One of the best variants is joint ownership. This could not only solve the questions of the
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regulation and use of the water, but could also stimulate moves towards the unification and integration of the states. The absence of such problems in the former USSR can be explained by the existence of common ownership at that time. It is just this joint ownership, but not the ideology, the politics, or other factors which united the peoples of the USSR then. Now it is the division of this property and the breaking of economic ties that is the reason for the present economic difficulties of the CIS countries. The common property of the central Asian countries can be formed by building new projects and admitting existing ones into a joint-stock company.

Kyrgyzstan suggests that the countries concerned should settle the question of the joint use of the river flows on the basis of commodity-market relations, which means giving the water a commodity status and selling it to other states. This approach is probably not practical. First of all, river water is not an article of trade in the ordinary sense. It cannot be packed, marketed or certificated, and its supply cannot be stopped for physical reasons. It is not absolutely clear how the transit of water as an article should be considered, co-coordinated and paid for when it passes through third countries, for example, its delivery from Kyrgyzstan to Uzbekistan through Tajikistan, or to Kazakhstan through Kyrgyzstan and Uzbekistan.

An often suggested palliative to selling water is in the form of share holdings for the development of water projects, but this concept is not sufficiently well founded. This is because the result of the functioning of any project is not only the running costs, but also the profit from selling its products and the services it provides. Therefore it is incorrect to only take into consideration the costs without taking into account the profits.

At present the most practical and most soundly based way of harmonizing the irrigation and energy interests of countries located in the lower reaches of rivers together with the interests of the upstream countries, is the scheme of compensation provided in the Agreement on the use of water-energy resources of the Syrdarya River signed in 1998, but in its detailed form. This Agreement operates in the manner described. For the countries where the flow is generated, calculations are made of the compensations worked out from the natural regime of their hydro units work (Kyrgyzstan—for the Toktogul, Tajikistan—for the Kayrakkum) without taking into account the interests of the downstream countries. Then a second version of the work of these same hydro units is calculated, but this time taking into account the interests of the downstream countries. The monetary difference between these two versions, and the losses and damage connected with the transition from the first version to the second, define the value of the compensations.

It is necessary to take into account in these compensation calculations all the losses, damage and costs. This corresponds to the well-known principle of the World Trade Organization: “The user pays” (UPP). This principle proceeds from the fact that in the price of natural resources, all kinds of costs should be taken into account that are connected with their use, including the cost of impacts on the environment concerned with the exploitation, processing and use of the given type of resource.

There is another frequently quoted principle: “the polluter pays”. In order to settle arguments the General Agreement on Trade and Tariffs (GATT) Panel considered this principle in 1987 and came to a conclusion that although OECD countries adopted it on a voluntary basis, it would not be a principle of GATT. The Panel stated that the
principles of “general agreements concerning the collection of a border tax” give a GATT country-member “an opportunity to follow the principle “the polluter pays”, but they do not oblige it to do so”. The GATT position can be explained by the fact that the principle “the polluter pays” is discriminatory for a national product and only makes it incur all expenses. As a matter of fact, the simple difference between these two regimes only determines the prime cost of services of flow regulation. In order to determine the price of these services it is necessary to add some norm of profitability to the prime cost.

In conclusion it can be noted that there are also more possibilities for solving this problem—the harmonizing of irrigation and energy interests. No matter how paradoxical it appears, the answer lies in the development of a greater number of hydroelectric projects. The point is that today’s contradictions hinge on the fact that there is only one large reservoir in each upstream republic namely: Toktogul in Kyrgyzstan and Kayrakkum in Tajikistan. It is evident that they cannot be operated for the requirements of energy and irrigation at the same time. If there were more reservoirs then this might be possible.

THE DIVISION OF WATER RESOURCES IN CENTRAL ASIA: POSSIBLE WAYS OF SOLVING THE PROBLEMS

Another very significant problem of the use of water and energy resources is how the water resources should be divided. It is the problem that causes the sharpest arguments, and frequently, mutual suspicions between the republics. This problem is rooted in the Soviet past. Now the most important point is the need for open discussion and the agreement of common principles.

Today the positions of Uzbekistan, Kazakhstan and Turkmenistan are to request the preservation of the existing limits to the division of the resources and the allocation of additional amounts for the Aral Sea and the Aral Shore. Kyrgyzstan and Tajikistan hold the position that there should be a reconsideration of these limits with an increase in their shares. Kyrgyzstan and Tajikistan maintain that they were deprived by water and that they did not get any compensation for this during the existence of the USSR. As a consequence they possess the smallest area of irrigated land per head by comparison with the other republics, and they cannot feed their populations at the minimum level of consumption from their own agricultural production. How fair are the proposals of the downstream countries to increase the volume water for the Aral Sea can be questioned. Kyrgyzstan and Tajikistan were always in agreement with them in this regard, as today’s situation in the Aral Sea zone negatively impacts on them too. The dust-laden, salty winds from the land exposed by the recession of the Sea spread these materials to the glaciers and cause them to thaw more rapidly. Separation of the Aral into two or more bodies of water is an expression of the additional water being used. There is no reliable and objective control of water use by the republics of the water users. Instead, limits could be set to the use of water by Uzbekistan and Kazakhstan. All the states do not have an equal responsibility for the destruction of the Aral Sea and they should not have equal participation in the allocations of water. Such allocations should be directed first to the republics, which sharply reduced the flow
into the Aral Sea in the period from 1960 to 1990 due to the rapid increase of irrigation on their territories, i.e. Kazakhstan, Turkmenistan and Uzbekistan. Both Kyrgyzstan and Tajikistan bear a minimal responsibility for this reduction.

Sometimes as an argument for the preservation of the existing division of water resources the downstream republics raise the matter of “historic” rights. But this approach cannot be recognized as realistic. In order to be really “historic” this right must, at least, be based on the use of water over a long period. For example, Turkey, Syria and Iraq share several basins where irrigation has been practiced for 4000 years or more, beginning with Sumeria, when the volume used in irrigation was approximately the same as today. This is unlike today’s demands for water by Kazakhstan, Turkmenistan and Uzbekistan, which are only guided by the situation in the 1980s. They attempt to secure as “historic” rights the maximum volumes that were achieved only once since irrigation was first practiced in the basin of the Aral Sea, which was unambiguously recognized as erroneous by all the central Asian republics both now and at the time of the former USSR. This is now regarded as the profligate use of the water–energy resources that led to the ecological disaster of the Aral Sea.

Experts, including those from abroad, suggest that the problems outlined here may be overcome by increasing the efficiency of irrigation. However, these hopes are exaggerated to a considerable extent. Such reforms need large injections of capital, and today both Kyrgyzstan and Tajikistan suffer shortages of finance, even for the more normal water development projects. The example of Israel which is often quoted is simply confusing. Israel can afford to implement projects using the most up-to-date technology, as that country has a high level of economic development. Our republics cannot be compared with Israel, which has far greater opportunities for attracting foreign investments.

Thus the only possible settlement of the water resources allocation problem remains the reconsideration of the existing quantities. There is nothing unusual in this. As practice shows, under the present conditions the volumes available and the needs for water are often the most flexible elements in international relationships. They are identified by certain conditions and depend on the reforms, development strategies, population dynamics and many other factors pertinent to the states. Kazakhstan serves as a good example. From 1998 to 2002 its demand for water in the growing season has decreased from $1100 \times 10^6 \text{ m}^3$ to $700 \times 10^6 \text{ m}^3$ in the Syrdarya basin at the expense of market reforms and the restructuring of agriculture. The need to change the existing allocation of water resources is also connected with the situation in neighbouring Afghanistan. After the stabilization of the situation Afghanistan made a request for a volume of up to $25 \text{ km}^3$ a year of water from the Amudarya River. This volume is not taken into consideration in today’s water and economic balances of the central Asian region.

Reconsideration of the allocations of water resources between the central Asian states is vital, if only because they are not legally assigned at the present time. The present quantities were established by the protocols of the scientific-technical councils of the USSR Ministry of Melioration and Water Economy in the 1980s. Even at that time they were not governmentally agreed, being simply departmental in character. At the present time, when neither the USSR Ministry of Melioration and Water Economy nor the USSR exist, they have no legal basis. Of course we should realize that the
reconsideration of the allocations is a complicated matter that will need a very careful approach. On the other hand, any attempt to avoid this reconsideration will aggravate the situation, and could lead to conflicts between the republics. Requests for reconsideration of the allocation of water resources have been advanced by Tajikistan and Kyrgyzstan, and reference has been made to Afghanistan’s request. There is still time today for an analysis of the situation, consultations and talks for the preparation and conclusion of appropriate agreements between the parties.

Relatively smooth mechanisms could be offered for the reconsideration of the existing division of water resources by Tajikistan and Kyrgyzstan. Additional allocations of water for them could be gained by the implementation of more efficient irrigation systems based on modern technology in Kazakhstan, Turkmenistan and Uzbekistan, where the previously irrigated areas could be maintained.

CONCLUSIONS

This analysis of this complex problem of central Asian water and energy resources shows that on the whole the region possesses the necessary resources and the potential for normal sustainable development. The main obstacle to the efficient use of these resources is not the economic difficulties from which all the republics of the region suffer, but rather handicaps imposed by the existing relationships between them. The breakup of the traditional ties and the euphoria of independence amongst the young states and the well-known populism of politicians are important factors. Top-priority today must be given to the establishment of good neighbourly and mutually beneficial relations between the republics of the region.