

1

Systems View of the Water Management in Central Asia

Genady N. Golubev

*Faculty of Geography, Moscow State University
Moscow, Russia
and the United Nations University
Tokyo, Japan*

Interdisciplinary and Multicriterial Objectives

The largest closed area in the world is situated in the middle of Asian continent, and a good part of it is called Central Asia. The latter is a region where high mountains and arid low-lying plains are not only neighbors but they constitute a system with water playing the key role in it. It is not simply a natural system, but ecological, political, social and economic one as well. Therefore, most of the problems in the system require an interdisciplinary approach. Besides, majority of problems have different objectives. These multicriterial problems cannot be solved to the satisfaction of all partners in a conflict (interest groups, social classes, nations, etc.), and a trade-off among the alternatives is a usual way of life. One has to deal with the systemic issues of multidisciplinary and multicriterial character. In all this complexity water resources and their use have a key role.

The Principal Features of Central Asia

On the south of Central Asia, its border is very well defined by the high mountain systems of Tian-Shan, Pamir (both with the altitude of up to 7500 m a.s.l.), Alai, Kopetdag, and others. Virtually all available water resources of the region are formed in high mountains of the south. More north, at the foot of the mountains, one finds an excellent combination of good, fertile soils, generous sunshine, and river water coming down from the mountains. The maximum of then river water is mostly in summer, when the plants' water demand is the highest. It is the zone where the traditional irrigation existed for millennia, and this is the center of ancient civilizations.

To the north, there is no natural border for Central Asia. The vast arid plains, with the altitude mostly of 100-200 m above sea level and, in some places, even below the sea level, extend well to the north, that is towards the south of Siberia. The southern part of this vast area is known as Kyzylkum and Karakum Deserts. Within some limitations, one can say that the northern border of Central Asia extends to where the waters coming down from the mountains dissipate.

From the water resources point of view, one can observe three main zones in Central Asia: the high mountain zone of run-off formation, the zone of predominant irrigation developments, mostly at the foothills, and the zone of run-off dissipation situated on the plains. The total area of Central Asia is about 1.5 million km², more exact figure depends on where to draw the northern border of the region in question.

Geographically, Central Asia is an area of few river basins extending north from the mountains to the deserts. In terms of run-off, it is one of the largest closed areas in the world. They are endorehic and arehic territories. The former means a territory with some run-off, but it goes down to depressions without giving any flow to outside the region, while on the latter territory the run-off is not produced almost at all.

The central, most important and clearly defined part of Central Asia is the basin of Aral Sea, that used to be the second lake in the world by its area. Aral Sea has only two tributaries, Amudarya and Syrdarya, while there is no any outgoing stream. There are also few smaller rivers going down to the north. Most of them used to be tributaries of Syrdarya and Amudarya during the periods of better climate. Due to the human activity (mostly the irrigation development) and the climatic oscillations, they dissipate at the foothills providing water for irrigation and do not reach Aral.

In terms of politics, under Central Asia one usually understands the territory of the former (until end-1991) Soviet Republics that belonged to the then USSR: The whole of Kirgizstan, Tadjikistan, Turkmenistan, and Uzbekistan, with the population of over 40 million, plus the southern part of Kazakhstan. Some parts of Afganistan and Iran (17% of the total of the basin) also belong to Amudarya River basin, but the involvement of these two countries in complex issues of water resources management is not yet on the agenda.

Water Resources of Central Asia

The figure of the total river run-off for Central Asia cited in a literature varies mostly between 110 and 120 km³ depending on the period chosen, the methodology to calculate the flow of

temporary streams and the accuracy of the run-off measurements. Few rivers flowing down from Kopetdag Ridge within Turkmenistan (Murgab, Tedjen and Atrek) do not change noticeably the figure mentioned above.

The annual river run-off of the tributaries of Aral Sea at the foot of the mountains for a relatively stable period of 1930-1975 was 112 km³ (Lvovitch, 1986).

Mean annual run-off of the rivers of the Aral Sea basin, 1930-1975, km³:

Syrdarya	Amudarya	Chu & Talas	Zarafshan	Kashkadarya	Total
38.8	61.3	8.46	2.56	0.62	112

Irrigation is far the main user of water withdrawing for each of the four countries between 84% and 91% of their total run-off.

The groundwater resources of acceptable quality, which are not hydraulically connected with the river systems, are about 2.5 km³/year (UNEP, 1993). Hence, the main source of water is the river run-off.

Additional resource, though of lower quality, is the irrigation return water. The volume of the return water is quite high depending largely on irrigation developments in the basin. For instance, the annual flow of Syrdarya River at the foothills of the mountains in 1930's contained 10% of the return water, but due to active hydraulic works in the basin by 1960's it carried in its total run-off up to 60% of the returned water (Rubinova, 1973). V.L.Shulz (1975), a leading hydrologist of Central Asia in the recent past, estimated for few major rivers, including Syrdarya, the share of irrigation returned water between 15 and 30% of the total run-off.

The per capita water resources for the total of four Central Asian countries (Kirgizstan, Tadjikistan, Turkmenistan, and Uzbekistan) is approximately 2800 m³ a year. It clearly places the region in the category of water deficient one. Adding up to this figure the return waters would slightly increase this index up to 3400 m³ per person a year, but still the region remains within the category of limited water resources. One should be reminded, however, that quite a

number of countries with well developed irrigation belong to the same category.

One distinctive feature makes Central Asia different from the many other territories. In order to maintain the water level of Aral Sea, one has to give water to the Sea. The first half of the 20th century clearly demonstrated that to keep the water level of Aral more or less stable, one has to give to the Sea about 55 km^3 of water a year. With this consideration in mind, the per capita water resources of Central Asia come down to 1400 m^3 per person per year. From this point of view, Central Asia faces already now a severe water deficit. It would become ever more grave as long as the population would grow, while water resources would keep stable. It may lead to a serious social and political insecurity in the region.

Sandra Postel (1999) mentions a value of 1700 m^3 per person as a world-wide critical index. She writes that as a nation's run-off per person drops below about 1700 m^3 , food self-sufficiency for the country becomes difficult, if not impossible. Below this value, there is often not enough usable water to meet the demands of industries and cities and to grow enough food for the entire population while at the same time sustaining river flows for navigation, fisheries, and other functions. Countries in this situation then begin to import water indirectly, in the form of grain.

The four countries in question are quite different from the point of view of water resources availability and their use: the most rich with water resources are Tadjikistan and Kirgizstan while the main water users are Uzbekistan and Turkmenistan. Potentially, this geographic situation is a source of conflicts.

The Aral Sea problem

Aral Sea is situated in a very arid region with annual precipitation of about 100 mm. On the area between the plains and the mountains precipitation is between 400 and 500 mm, and in the mountains it exceeds in some points 2000 mm. The total amount of precipitation on the basin of Aral Sea is about 500 km^3 a year, and the run-off is about $110\text{-}120 \text{ km}^3$. Syrdarya and Amudarya at their mouths used to carry to Aral Sea about 55 km^3 a year. That was enough to

maintain the oscillations of water level within 2-3 m during 1860-1960.

At the end of the 1950s the leadership of the USSR made a decision on an extensive development of irrigation in the Aral Sea Basin. It was believed that the irrigation may become the main remedy in solving many agricultural problems of the USSR. It was expected that the expansion of irrigation in Central Asia would bring the prosperity both for the region and to the USSR as a whole. It was clear to the water resources experts that one of the main side effects would be the deterioration, if not the disappearance, of the Aral Sea. However, that time it was not considered as an important issue.

Investments in the irrigation of Central Asia during 1960s-1980s were of the order of 50 billion dollars (The conversion rate between the Soviet Rouble and the US Dollar is very approximate). The area of irrigated lands in the Aral Sea basin has increased from 5 million to 7-8 million hectares. The consumption of water is excessive. Each hectare of cotton requires there about 17,000 m³ a year, while the standard figure would be 8000 m³. The new 3 million hectares for irrigation would mean eventually 51 km³ of water a year not coming to Aral Sea, in addition to 55 km³ traditionally taken. The approximate figure of 106 km³ is what is used in the basin of Aral Sea and, hence, what the lake does not receive. It means that the river water have reached Aral only in the years with flow above average. The last figure is quite comparable with the volume of the flow of Syrdarya and Amudarya. Indeed, during 1990s some river water reached Aral in the water-abundant years. The gradual development of new irrigated lands meant a steady decrease in the inflow to the Lake and the deterioration of the Sea:

Year	Water level m a.s.l.	Area 000 km ²	Volume km ³	Salt content g/l
1960	53.3	67.9	1090	10.0
1970	51.6	60.4	970	11.1
1980	46.2	52.5	670	16.5
1990	39.0	38.0	300	29.0

Within 30 years (1960-1990) the water level of Aral Sea dropped down by 14.3 m. The volume decreased by 790 km³ or 3.6 times, and the surface has shrunk by almost 30,000 km² or 1.8 times. The

mean depth changed from 16.0 m to 7.9 m. By 1995 the water level dropped by 2 m more. The salinity of water in the lake reached the oceanic one, that is 35 g/l.

In 1988-1989 two parts of the lake, - the smaller northern part called Small Sea or Small Aral and the larger southern part called Big Sea or Big Aral divided completely. Some Syrdarya water goes predominantly to Smaller Sea, and its water level became more or less stable. The area of Big Sea keeps shrinking. Big and Small Seas are connected with a strait through which some excess water from the latter go to Big Sea.

The Large-Scale Water Transfers

Some estimates indicate that about 90% of water resources in Central Asia are already in use while the population keeps growing with the rate of 800-900 thousand a year. It is well known that there are two strategic solutions of a looming water crisis: to look for an additional water supply sources or to improve the methods of more efficient use of available water. The main strategy in the region was the former, but the surface water resources are practically exhausted and groundwater resources are very limited.

The only large-scale option to increase the availability of water resources was to take a part of water from the mighty rivers of Siberia flowing North and to transfer it by way of a system of water reservoirs, pumping stations and large, long canals to the South, that is to the North of Central Asia. The length of the main canal would be of the order of 2000 km with the water discharge of about 25-50 km³ per year. The project would be very costly.

In 1960s – 1980s the projects of large-scale water transfers were quite popular in many countries. The world-wide experience, including that of Central Asia, has been put together in two books (Golubev and Biswas, 1979; Golubev and Biswas, 1985).

In the Soviet Union, the water transfer projects were considered as the main solution to the water deficit, with the expectations to increase the productivity of agriculture among other problems. The gains were obvious: new water would be a good combination with the lands to be irrigated. Besides, the indigenous population was

growing in numbers creating the occupation problem. Rural people wanted to keep working on land, without migrating to the cities. Uzbeks and Tadjics in particular, they are very good to work in irrigation. In this way, the social problems, such as an employment would be also solved somehow.

Many research and design institutions have been working in the USSR on various aspects of the water transfers. They brought, however, the conclusions which contained both positive and negative features. The main drawbacks of the water transfers are as follows:

- Very high cost of the project and a high cost of a cubic meter of the transferred water;
- The environmental consequences would be many, some of them are presently unpredictable.
- There is no reliable methodology to integrate the environmental costs into the total costs.
- For economic reasons, by necessity, the main conveyance canal would be unlined. That would lead to the great losses of the transferred water and deterioration of its quality.
- At the best, the Siberian water would get to the lowest reaches of Syrdarya River, that is to the least productive lands within Central Asia. Then the Central Asian water currently used there would be withdrawn in the middle part of Syrdarya basin. It does not look like a solution for the whole of Central Asia. Redistribution of the Siberian water all over Central Asia would be also very costly and technically complicated.
- The removal of large part of water from Siberia south would bring serious ecological consequences. Some of them might be positive because, for instance, some bogs might get drier. At the same time, in total, the biological productivity of the Ob River system would be less than now.
- The redistribution of water among the states of Central Asia and the subjects of the USSR and, later, the Russian Federation, is a very difficult problem both legally and politically. Presently, it is difficult to imagine how this problem can be solved.

Concluding this discussion, one can say that the large-scale transfer of Siberian water to Central Asia is a very complex problem,

difficult, if not impossible to be solved, from the political, economic, environmental, technical, juridical, etc., points of view. Besides, the indigenous Central Asian water is not efficiently used, and some good reserves can be found in a better water management, without making very costly constructions and not very well known consequences.

Improved Water Management

The water consumption in Central Asia is excessive in general and the effectiveness of water management remains to be improved. Perhaps, the main reason for the low efficiency is the lack of economic interest to save water. Of course it is a typical case in quite many regions of irrigation. In Central Asia, the efficiency of irrigation systems is between 55-65% due to a seepage from the distributing canals and a predominantly furrow method of watering. The main canals are mostly unlined. As have been said already, the large volumes of agricultural return water cause pronounced changes in the hydrological and geochemical regimes.

The actual water consumption of crops exceeds their necessary consumption by 150-200% (Glazovsky, 1990). One of the ways to cut the excessive water consumption is to cut planting such crops as rice for the reasons of water management efficiency, and other cereals for economic reasons. To stop irrigating 15% of the land of Central Asia being of the lowest productivity, would save about 20 km³ of water. The plantations of rice of low quality, but of a high water consumption, have already been reduced.

Improved efficiency of irrigation systems seems to be the main and the last reserve for Central Asia. It is expected that the presentations made at this Workshop and the ensuing discussion would update our common knowledge about a progress in efficient irrigation techniques.

Irrigation and environment

In the irrigated areas a new, ample network of the irrigation and drainage canals have been formed. The level of ground water has gone up drastically in many places due to the seepage causing widespread water-logging. There, the salinization of soils is also a

major problem. Large losses of water are characteristic of all levels of the irrigation network. Correspondingly, the vegetation and ecosystems change considerably creating lakes, ponds and bogs in the predominant landscape of deserts.

A characteristic feature of the agricultural part of Central Asia is large canals. The largest in Amudarya River basin are Karakum (11 km^3 a year), Amu-Bukhara (5.8 km^3) and Karshi (3.6 km^3). In Syrdarya River basin they are Large Fergana (3.4 km^3) and Yuzhno-Golodnostepsky (3.4 km^3). Many of these canals loose a lot of water due to the seepage. A good part of water filtering through the grounds comes out to the surface forming small and large lakes and ponds. The total area of such ponds in the basin of Aral Sea is over 7000 km^2 . The largest two are Sarykamysh in the basin of Amydarya with the surface of about 3000 km^2 and volume of 26 km^3 , and Arnasai in the basin of Syrdarya ($1800\text{-}2400 \text{ km}^2$ and, correspondingly, $12\text{-}20 \text{ km}^3$). These two lakes receive annually $4.5\text{-}5.0$ and $2.1\text{-}2.3 \text{ km}^3$ of the return water correspondingly (Mikhailov and Gurov, 2000).

Geochemical Aspects of Water Management

The development of irrigation is associated with massive and pronounced changes in the chemical state of the environment. Under natural conditions, the soils of agricultural areas of Central Asia contain large amounts of salts in the vertical profile. When irrigation is introduced, new additional portions of water seep down through the soils profile dissolving the salts and making them to move in the artificial or natural drainage systems. Therefore, a massive irrigation development means also the change in the geochemical regime at a regional scale.

In Central Asia, the direction, intensity and composition of the salts transport have modified considerably. The expansion of irrigation has lead to the increase of the salts movement mostly with the drainage run-off. It has been calculated that the salts transport in the Aral Sea basin has increased about two times and is now up to 120 million tonnes a year (Glazovsky, 1990). During 30 years (1960-1990) of a remarkable irrigation development a huge amount of three billion tonnes of salts were moved within the basin. Of this volume, 60% have accumulated nearby, in local ecosystems, small

new lakes and bogs, 27% have gone to the two large new lakes, Sarykamysh and Arnasai, mentioned above, and 13% reached Aral. Moreover, the transport of sodium, chlorine, sulfate and magnesium has increased much more than that of the other main ions like calcium or carbonate.

Wind erosion of the former bottom of the Aral Sea has increased greatly, 0.5 to 3.5 times, in different points around the lake. The salts transport goes along with it taking away between 1,000 and 10,000 t/km² per annum. For the whole former lake bottom it comes to about 100 million tonnes a year.

Transport of salts with the drainage water, wind and groundwater together with the raise of the groundwater level leads to the progressive salinization of soils. Soils with a medium and high degree of salinization occupy from 35 to 80% of the irrigated areas in Central Asia. Water logging is another serious widespread problem. The land losses due to water management activities are of the order of 1 million hectares. In fact, when designing a new irrigation system, one has to build on a combination of water resources and the salts transport.

The environmental degradation, namely unacceptable drinking water quality, high salts contents in the air, and, possibly, large concentration of pesticides residues in the agricultural produce have made direct impacts on the state of human health in the Aral Sea basin. The worst situation is where the above factors make the most unfavorable combination, that is around Aral Sea, particularly in the lower reaches of Syrdarya and Amudarya.

The medical indicators there are astonishing. For instance, for a number of districts in the lower reaches of Syrdarya River the infant mortality is comparable with that of the least developed countries. The number of cancer cases in the lower reaches of Amudarya is 7 times the former USSR basin. Over 90% of the population there suffer from anaemia. It is 60 times more than the average for the former Soviet Union. There are many more indicators of the environmental crisis. One can say that the water level of Aral Sea is an index of the difficult social-economic situation in the whole region of Central Asia. The contribution to improve the state of

Aral Sea may be made indirectly, by means of actions in social-economic sphere.

Environment and Development

The development strategy for the region has been adopted about fifty years ago. It is obvious now that it was wrong. It has lead to the environmental catastrophe, maybe the largest in the world. The strategy has proved to unsustainable. A new development strategy for the region is urgently needed.

The most urgent problem is an expeditious improvement of the environment for the population, in particular in the areas close to Aral Sea. Major water conveying pipelines transporting water of acceptable quality have been built and many desalination stations have been put into the operation.

A comprehensive, long-term program of the land-and-water resources management should be one of the cornerstones of the strategy. It should contain such elements as dropping low productivity lands from irrigation, increase of efficiency of the irrigation systems, drastic reduction of water applied for a unit of cropland, diversification of crops and liquidation of the cotton monoculture, optimal use of fertilizers and pesticides, application of the integrated pest management systems.

However, the strategy must go well beyond the modern land-and-water management program. It should go to the roots of the catastrophe addressing principal social and economic problems such as population control, a balanced ratio between the demand and supply of cotton, an appropriate structure for crop and livestock production, development of the agricultural extension services, conversion of industry from the military production, and considerable improvement of the social amenities including education at all levels and reasonable medical services.

Much care should be devoted to cooperation among the nations of the region as the only basis for the lasting, sustainable development of the potentially rich territory of Central Asia.

International Issues of Water Management

Central Asia has quite high rate of population increase. The development of irrigation could not absorb the growing population, and unemployment is high. There is a danger of increased tensions among the neighbors. The national boundaries drawn in 1920s in some places do not adequately reflect the realities. Under these conditions, the management of a large, multinational natural system is not a simple task.

With the break up of the Soviet Union the water management situation in Central Asia have changed. In place of one large country, presently the five new countries have to operate in sharing the water resources mostly of just two rivers. Afganistan may come up as the sixth partner. Russia cannot be discounted as it is the source of large water resources relatively nearby.

Kyrgyzstan and Tadjikistan are the areas of predominant river run-off formation, with the water used for irrigation in the low-lying Uzbekistan, Turkmenistan and in the south of Kazakhstan. To smooth out the variations of river flow within a year, a number of water reservoirs have been built, including such large reservoirs as Toktogul in Kyrgyzstan and Nurek in Tadjikistan. These two countries do not have enough hydrocarbon natural resources as the main source of their energy production. The overall objective in water management of Kyrgyzstan and Tadjikistan is to release a good part of water from the reservoirs in winter season to produce energy while the low-lying countries, Uzbekistan in particular need water for irrigation during summer. Potentially, it is a conflict situation.

The Karakum Canal built in Turkmenistan during the last few decades takes more than 10 km^3 of water a year. Apparently, there is no way to reduce this withdrawal as the new settlements based in the area of the canal on the Amudarya water and situated in Turkmenistan have to be maintained.

The shores of the Aral Sea belong to Uzbekistan and Kazakhstan, but huge amount of water needed to maintain the water level of the lake comes mostly from the mountains and, hence, from the other countries.

All these and similar problems are a potential source of international conflicts. There is no way to solve these problems through conflicts. The mainstream way is the international cooperation in system-wide improvement of all aspects of water management on the long-term basis.

References

- Glazovsky N.F., 1990. Aral crisis: the reasons of emergence and the ways for solution.- Nauka, Moscow. (In Russian).
- Golubev G.N. and Biswas A.(Eds.), 1977. Interregional water transfers. Problems and prospects. Pergamon Press.
- Golubev G.N. and Biswas A. (Eds.), 1985. Large-scale water transfers: emerging environmental and social experiences. UNEP. Tycooly Publishing Ltd., Oxford.
- Lvovich M. I., 1986. Water and Life. "Mysl", Moscow. (In Russian). 254 p.
- Mikhailov V.N. and Gurov F.N., 2000. On the Causes of the Aral Sea Level Fall. Vestnik Moscovskogo Universiteta, Serie 5, Feography. No.4, 2000.
- Postel S., 1999. Pillar of Sand. W.W.Norton & Company. N.Y.- London.313 p.
- Rubanova F. A., 1973. Change in the Structure of the Water Balance of Syrdarya River Basin upstream of Chardara, under the Influence of Hydraulic Constructions. Proceedings of the State Hydrological Institute, No.208, Leningrad. (In Russian)
- Shulz V.L., 1975. Water Balance of the Aral Sea. Proceedings of SARNIGMI [Central Asian Research Institute of Hydromelioration], No. 23. (In Russian).
- UNEP, 1993. A diagnostic study to develop a Plan of Actions to save Aral Sea.- UNEP, Nairobi, Kenya.