Impacts of climate change on water resources in Central Asia

Sulton Rahimov
Former chairman of the executive committee of the International Fund for Saving the Aral Sea (IFAS)

Abstract
This article focuses on the impacts of climate change phenomena on water resources in Central Asia. The text begins with a geographical description of the region, specifically the degradation of the Aral Sea and the economic and environmental consequences of climate change, due to the importance of water resources for the development of the region. In this context, the text analyses the impacts of climate change on glaciers and surface water resources in Central Asia, and offers some future predictions concerning the reduction of glacial areas and river flow, as a consequence of rising temperatures.

Given the predicted hydrographic changes in the region, the author presents some of the socioeconomic and ecological series of impacts for Central Asia countries. Finally, in order to deal with this future scenario, a few measures for mitigating climate change are set out, such as the reduction of greenhouse gas emissions, the use of renewable energy sources, other technical measures regarding control and data compilation such as the restoration of hydrological meteorological stations, and finally the author calls for a new strategy on water resources management in the interest of all the countries in the region, in order to tackle the threats to sustainable development and security in Central Asia.
Central Asia: general information

Central Asia is located in the centre of the Eurasian continent—at the interface of Europe and Asia—and occupies an area of about 4 million km$^2$. The region covers the territory of five countries: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan, which are home to almost 60 million people. Central Asia shares borders with Afghanistan, Iran, China and Russia. Its nature is presented by the highest chain of the Pamirs and the Tien Shan, broad deserts and steppes, while the large Asian rivers are the Amu-Darya, the Syr-Darya and drainless reservoirs, the largest of which are the Caspian and Aral seas. The overwhelming part of the Central Asia region is located in an arid zone, the main distinction of which is a deficit of fresh water.

In the last third of the 20th century, Central Asia suffered an ecological crisis on a planetary scale—the degradation of the Aral Sea, once the fourth largest lake of the world in surface area. The Aral Sea began to dry up owing to excessive water intake for irrigating newly developed virgin lands in its basin. So, from 1960 till 1990 the area of irrigated lands almost doubled (from 4.3 million ha to 8.2 million ha) as a result of which water intake for irrigation also doubled. As a consequence, by 1990 the water level in the Aral Sea had fallen by more than 20 m, while the water area was reduced by more than three times. At present, the level of the Aral Sea is 28.60 m to the level of the Baltic Sea and it continues to dry up—by 2007 its level fell by 1 m more. Today, water volume in the sea in comparison with 1960 has reduced by more than 10 times, reaching 93.1 km$^3$, while the water area has reduced by 5 times (12.37 thousand km$^2$ against 68 thousand km$^2$ in 1960).

The consequences of the Aral Sea crisis have been negatively reflected in the socio-economic development of the region. The irrational use of water and land resources led to the increase of mineralization in water resources and a salinity of soil, the deaths of fresh-water lakes and many kinds of fresh-water flora and fauna, the incidence of salt storms, desertification, the worsening of public health and the quality of drinking
water and the loss of fishing grounds. Some estimate that the economic losses connected with the Aral Sea crisis reach the massive sum of up to several hundred million US dollars in a year.

Central Asia’s countries are making considerable efforts to mitigate the consequences of the Aral Sea crisis, but the situation is aggravated by new global challenges, and especially by global climate change, the influence of which is more tangible in this region.

**About climate change**

Climate change is one of the most important problems for the environment; it is caused by high concentrations of greenhouse gases in the atmosphere, which leads to the intensifying of the greenhouse effect and a rise in global temperatures. Sources show that considerable climatic changes occurred repeatedly in the past. However, these changes were caused exclusively by natural factors. The present climatic changes are undoubtedly caused by intensive human activity. Industrialisation, urbanisation, increasing volumes of industrial and agricultural production, the development of motor transport and road economy, in addition to socio-economic benefits have all resulted in an increasing anthropogenic influence on the environment and climatic system, raising the volume of the emissions of greenhouse gases.

The Intergovernmental Panel on Climate Change determined that for the last 100 years (1906-2005) the average temperature of the Earth's surface has risen approximately by 0.74°C; thus the average indexes on warming for the last 50 years almost double the indicators for the last 100 years. The data also specify that the quantity of ice in the Arctic has been decreasing on average by 2.7% every 10 years, while the level of the world's oceans has risen on average by 17 cm in the 20th century. Scientists and experts have linked these figures on climate change with phenomena observed during recent decades such as powerful thermal waves, new wind conditions, frequent droughts, catastrophic flooding, abundant precipitation, thawing
snowfields and glaciers, the reduction of ice volumes in the Arctic waters, as well as the increase of the world’s oceans.

In each of the coming two decades, scientists forecast a future warming of approximately 0.2°C, connected with a lack of actions implemented for reducing the amount of greenhouse gases. Experts are concerned about the reducing of efforts on poverty control due to climate change. So, according to data from the United Nations Human Development Report for 2007, as a result of global warming, about 332 million people, living in coastal or waterside areas will be ecological refugees. 70 million people in Bangladesh, 6 million people in Egypt and 22 million people in Vietnam will be victims of flooding. 1.8 billion people around the world will have no access to drinking water. To prevent such a scenario the authors of the report suggest that all countries should develop adaptation plans for future changes, and that industrialized countries should reduce emissions of greenhouse gases by 80% by 2050. Failure to address this problem will result in 40% of the poorest population of our planet (about 2.6 billion people) being doomed to a future with progressively decreasing possibilities.

The influence of climate change on public health, economy and the environment

Climate variability produces very negative effects on the health of populations, promoting an increase in “thermal” diseases, death and trauma as a result of natural disasters. Climate change also promotes the occurrence of outbreaks and epidemics of infectious-parasitic diseases connected with rising temperature and air humidity.

The influence of climate change is very considerable on agriculture, hydropower and transport infrastructure, which are a source of economy development for the region. The most vulnerable sphere in this plan is agriculture and, in particular, irrigated agriculture, which consumes the lion’s share of water resources and provides employment for a large
part of the rural population. Vulnerability of the rural population is also caused by an increase in natural hydrometeorological phenomena. The negative consequences of climate change for hydropower at a given stage are mainly landslips and mud-flows, thus promoting an increase in the silting-up of reservoirs. The decrease in river flow, which is expected over the medium and the long-term, will also be unfavourable for hydropower. The influence of climate change on transport infrastructure is especially typical for highmountainous regions where the main part of this infrastructure are the highways on which the basic proportion of goods turnover takes place.

The influence of climate change is more obvious on the environment. The speeding-up of processes of land degradation and desertification, the acceleration of natural hydrometeorological phenomena and the loss of efficiency of ecological systems all point to an increase in active climatic fluctuations in the region.

However, experts consider that water resources are especially vulnerable to the influence of climate change. Rising temperatures have already speeded up the hydrological cycle. A warmer atmosphere retains more humidity, becomes less stable and, as a result it leads to an increase in precipitation. Rising temperatures also speed up the evaporation process. The loss of quantity and quality of fresh water resources will be the end result of these changes in water circulation in all the different regions. In regions with a temperate climate, the thickness of mountain glaciers and snowcaps have already reduced, and especially during spring.

The glaciers of Central Asia have undergone considerable changes owing to global climate change. According to some data, in recent decades their surface area has reduced by 30-35%. Changes in areas of glaciations and the snowiness of a zone of flow formation can have considerable influence on hydrological regimes and water resources. Considering the key role played by water resources in the socio-economic development of the countries in the region, such a trend can lead to major negative consequences during coming decades.
Central Asia’s water resources and their importance for the region

In Central Asia, water is life. It represents the basis of socio-economic development for the countries of the region and also a major link for national and regional security. More than 90% of the region’s water resources are used for irrigated agriculture, which produces about 30% of the regional GDP and provides employment for more than 60% of the region’s population. The proportion of used by the region out of the total electricity consumed is 27.3%. In some countries (Tajikistan and Kyrgyzstan) this figure rises to over 90%, a fact that shows a clear dependence of these countries’ economies on the availability of water resources.

Water resources allocation throughout Central Asia is non-uniformly that predetermines necessity of interaction of all countries of the region for their management and use.

The water resources of Central Asia consist of the river flow formed owing to water from atmospheric precipitation, melt glacial waters and underground waters. Table 1 shows the volumes of surface flow of the large rivers of region –the Amu-Darya and the Syr-Darya, which are of particular interest owing to their special importance, both for economic management and for geopolitical purposes.

There are more than 4,000 reservoir-lakes and water reservoirs in Central Asia. The largest of them are: the diminishing Aral Sea, one of the deepest lakes of the world –Issyk Kul (668 m), Lake Balkhash and Lake Sarez. On the Naryn river lies the Toktogul reservoir measuring 19.5 km³, while on the Vakhsh river there is Nurek reservoir (10.5 km³). Along with them there are more than 3,000 very small high-mountainous glacial lakes, tens of seasonally regulated reservoirs of, and thousands of basins and ponds of a decade and daily regulation.

The underground water resources of Central Asia within the framework of the Aral Sea Basin are estimated at 43.77 km³, with available resources totalling 15.83 km³.
Table 1. Formation of surface flow in the Aral Sea Basin

<table>
<thead>
<tr>
<th>Countries</th>
<th>Amu-Darya River</th>
<th>Syr-Darya River</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>km$^3$</td>
<td>%</td>
<td>km$^3$</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>0.00</td>
<td>0.00</td>
<td>4.50</td>
</tr>
<tr>
<td>Kyrgyzstan</td>
<td>1.90</td>
<td>2.42</td>
<td>27.40</td>
</tr>
<tr>
<td>Tajikistan</td>
<td>62.90</td>
<td>80.17</td>
<td>1.10</td>
</tr>
<tr>
<td>Turkmenistan with Iran</td>
<td>2.78</td>
<td>3.54</td>
<td>0.00</td>
</tr>
<tr>
<td>Uzbekistan</td>
<td>4.70</td>
<td>5.99</td>
<td>4.14</td>
</tr>
<tr>
<td>Afghanistan</td>
<td>6.18</td>
<td>7.88</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>78.46</strong></td>
<td><strong>100.00</strong></td>
<td><strong>37.14</strong></td>
</tr>
</tbody>
</table>


Table 2. Underground water resources of the Aral Sea Basin

<table>
<thead>
<tr>
<th>State</th>
<th>Estimation year</th>
<th>Regional resources km$^3$/year</th>
<th>Proven available resources, km$^3$/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kazakhstan</td>
<td>1990</td>
<td>1,845</td>
<td>1,224</td>
</tr>
<tr>
<td>Kyrgyzstan</td>
<td>1990</td>
<td>992</td>
<td>688</td>
</tr>
<tr>
<td>Tajikistan</td>
<td>1994</td>
<td>18,230</td>
<td>6,016</td>
</tr>
<tr>
<td>Turkmenistan</td>
<td>1994</td>
<td>3,033</td>
<td>1,120</td>
</tr>
<tr>
<td>Uzbekistan</td>
<td>1990</td>
<td>19,679</td>
<td>6,781</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>43,769</strong></td>
<td><strong>15,829</strong></td>
<td><strong>6,817</strong></td>
</tr>
</tbody>
</table>


The main sources for river flow in Central Asia are glaciers and snow-fields, providing 25-30% of annual flow and up to 50% for the vegetative period. They are distributed unequally through the countries of the region. Within Kyrgyzstan there are 8,200 glaciers with a total surface area of 8,169.4 km$^2$, occupying 4.2% of the country’s territory. Ky-
The number of glaciers in Tajikistan is 14,509 with a total area of 11,146 km$^2$, or about 8% of the country’s territory. The total ice reserve in glaciers is 845 km$^3$. Other glacial areas in Kazakhstan can be found on the Zailijsky Ala Tau, Jungarsky, Kungey and Terskey Alatoo ranges, and an inconsiderable part on Uzbekistan’s territory (basically in the Ojgaing Basin with a glacial area of 59.5 km$^2$).

The glaciers are more subject to the influence of climatic change, which leads to the reduction of the flow of melt water into rivers. The water flow accumulated in glaciers is important during years of little precipitation, and at the end of summer when seasonal snow cover has mostly thawed. Thus, glaciers act as buffers, operating as flow regulators and providing security during periods of low flow. Over the short-term, thawing glaciers will provide an inflow of additional water into rivers, though in the more remote future, when glaciers thaw, their buffer effect will disappear. Thus, there will probably be an increase of flow changeability with an according change in its reliability (Kotlakov; Seversky, 2006).

The impact of climate change on water resources in Central Asia

The impact of climate change on glaciers

Glaciers are one of the striking indicators of climate change and, to a certain extent, an environmental reaction of a zone of flow formation to global warming. At present in Central Asia there is an intensive reduction in glaciations, which explains the increase in the general background temperature and the change in the nature of precipitation. Sources show that during the period 1956-1990, the glacial resources of Central Asia were reduced by more than three times, and they continue to be reduced at an average rate of 0.6-0.8% a year of glacier area and about 0.1% of ice volume (Seversky; Tokmagambetov, 2004).
Observations of Tien-Shan’s glaciers show that a warming climate leads to their steady reduction. So, on Tuyuksu glacier (located in the ridges of the northern Tien-Shan) and Kara-Batkak glacier (Issyk Kul mountain range), glacier surface area from 1957 to 1997 reduced by 16.5 and 18.0 meters, or more than one-third of the glacier’s average thickness. The largest glacier in the Kyrgyz Ala Too –Golubin Glacier– shrank by 6m from 1972 till 1993 (Podrezov; Dikikh; Bakirov, 2003). On Ak-Shyjrak massif, for the period of 1943-1977, in height intervals of 3700-3900 meters, glacier surfaces reduced by 13,3-14,4 meters, and of 4,800-5,000 meters–3.7-6.0 meters (Kuzmichenok, 2006). Observations show that glacial areas of Kyrgyzstan could be reduced approximately by 20% since the creation of the “Catalogue of USSR glaciers” in the 1950’s-60’s.

Tajikistan’s glaciers, which form a considerable part of the glacial river flow of Amu-Darya basin, are subject to considerable influence by climate change as well. The surveys of the front of Zeravshan Glacier showed that from 1908 till 1986 it actively degraded and reduced by almost 1 km. The lower border of Abramov Glacier from 1850 till 1984 retreated by 80m, while the ice volume on the glacier tongue decreased by 630 million m$^3$. Fedchenko Glacier which, at over 70 is the largest in the country, reduced by almost 1 km during the 20th century, while its surface area decreased by 11 km$^2$ and it lost about 2 km$^3$ of ice. Thus all the inflows on the right have almost separated from it, becoming independent glaciers. Now the lower part of the glacier is broken up for 6-8 km into cracks and covered by glacial lakes that testify to the continuing degradation of this, the largest glacier in Central Asia. According to the most conservative assessments, the glaciers of Tajikistan have lost more than 20 km$^3$ of ice in the 20th century. Intensive degradation has affected small glaciers with areas of less than 1 km$^2$, which make up 80% of all glaciers.

1. Climate change - forecasts of Tajik experts. Dushanbe, 2002. Results of expeditions organised by the Executive Committee of the International Fund for Saving the Aral Sea (IFAS), the Regional Center of Hydrology (RCH) and the National Hydrometeorological Services (NHMS) of Tajikistan, 2005-2006.)
In Kazakhstan’s mountain systems, a reduction in the number and size of glaciers is also observed. Most intensively, glaciation decreased from the middle of 1950 till 1980, reaching a maximum in the first half of the 1970s. During the period from 1956 till 1990, glaciations in the mountains of south-east Kazakhstan was reduced by an average intensity of 0.85% a year as regards glacier area, and 1.0% in ice volume (Alamanov et al. 2006).

The arranged research shows that glaciers—depending on their size, character and height—react differently to climate changes. So, on Glazyrin’s assessments (2006), the higher that river basins are located, the steadier the glaciations. Exactly because of this, the Pamirs glaciations (which on average lay higher), was reduced to less than the lower glaciations of Gissaro-Alay. Data also show that the smaller a glacier is, the more it is subject to the influence of climate change. Furthermore, it was shown that the ablation of small glaciers is more intensively at the edges than in the middle. Glacier location also has a considerable influence. So, the glaciers lying on slopes of southern rhumbs are on average more resistant to climate change, and are reduced more slowly than on the slopes of northern rhumbs. And this is true in spite of the fact that they are, as a rule, smaller in size (Glazyrin, 2006).

The experts claim that if rates of glacier thawing are halted saved, then over the medium and long-term, the flow of mountain rivers will be lowered twice more.

**Impacts of climate change on surface flow**

Observations show that climatic changes have considerable influence on the hydrological regime of surface flow. In regions where the essential part of river flow is at present formed from melt waters, the maximum flow values will move from spring to winter, whereas the majority of precipitation will fall there in watery form because of high air temperatures. The increase of river flow in high latitudes—and also its decrease—is characteristic of Central Asia.
Hydrometeorological observations showed that the asynchronous course of atmospheric precipitation and air temperature in the high-mountain zone of Tien-Shan negatively affects the balance of glaciers and is reflected in the general water content of rivers, with a considerable glaciation of catchment areas (>10%). Thanks to negative trends in precipitation and positive trends in temperatures in the rivers on the northern slopes of Kyrgyz Ala-Too, Terskey Ala-Too and large inflows of the Sary-Jaz river, the flow for the period of 1963-1990 (in comparison with the flow for 1930-1960) increased by 11.0-28.6% in July, while annual values increased by 11.3-17.1%. The implemented estimate of the change of volumes of glacial flow of the Naryn river (being a basic component of Syr-Darya) by 2010, in conditions of continuing warming, showed that they will increase in the basins of all its main inflows that will lead to growth in the general flow (Podrezov; Dikikh; Bakirov, 2003). This conclusion has been based on the analysis of hydrometeorological conditions for 1991-2000, when average summer temperatures for a high mountain zone were above the norm by 0.6 °C, and July temperatures by 0.9 °C. The precipitations here were lower than the norm by 22%, while in the mid-mountain zone they were near the norm. Thanks to these conditions of warming and humidity, the annual flow of the Naryn river exceeded its average water content for 1991-1996 by 15.7%, thus a compensating role of glacial flow was clearly shown here. According to data from V. Kuzmichenok (2006), the total river flow in Kyrgyzstan increased by 6.2% from 1972 till 2000.

The dynamics of river flow during the decades (data from NHMS of Tajikistan) shows that in Tajikistan a general tendency was observed of a decrease of surface flow during the period of 1971-1980, in rivers with a snow-glacial source type within 11-14%, and snow-rain 8-21%. In the following decade, 1981-1990, the flow volume in rivers with a glacial-snow source type decreased a little (1-10%), and in rivers with snow-glacial and snow-rain source type it increased
(5-25%). A mid-annual flow volume for the period of 1990-2000 rose with respect to the last decade because of an increase in precipitation and temperature rise. During the period of 1961-1990, the total amount of the average annual flow formed in the territory of Tajikistan decreased by 4 km$^3$/year, i.e. an annual reduction of flow that represents 0.13 km$^3$/year.

According to data from the Scientific-Information Centre of the Interstate Coordination Water Commission of Central Asia (SIC-ICWC) the flow of the Syr-Darya river and its inflows for the last 17 years totalled 41.6 km$^3$, that is, above the mid-long-term and annual volume for 1950-1990 by 3.4 km$^3$ (or 8%). If we compare the average values of annual flow of the Syr-Darya river for 17 years with the mid-long-term flow for the entire period of observation of 1911-2007 (37.6 km$^3$) then the flow growth for 17 years will be higher (10%). The flow of the Amu-Darya river and its inflows for the last 17 years totalled on average 69.2 km$^3$, that is, lower than the mid-long-term annual volume for 1950-1990 by 1 km$^3$ (1.5%), but it practically coincides with the mid-long-term flow for the entire period of observation (1911-2007) –69.3 km$^3$ (Dukhovny et alias, 2008).

Thus, it can be stated that in general, river flow did not undergo special changes, though its interannual fluctuations with inconsiderable deflections are obvious. At a given stage, both increase and lowering of river flow is observed simultaneously, depending on the nature of their nourishment. According to data from Agalceva (2002), a river flow with a snow source type reduces faster according to rising temperatures. The rivers with considerable contribution from glacial flow are more “inert” in this plan, as temperature rise intensifies the thawing of high-mountain snow and glaciers, creating some compensation conditions for flow formation. At the same time, in connection with the continuing degradation of glaciation which progresses with rising air temperatures, it is estimated that there will be flow reduction here as well, probably, even more actively (Agaltseva, 2002).
Impacts of climate change on water resources in Central Asia

Prediction assessment of climate change influence on glaciers and river flow

For research of possible scenarios for climate change in Central Asian countries, the following different scenarios and models of global climate change—HadCM2, CCCM, GFDL, GISS, UK-89, ECHAM4, GFDL, IS92 etc.—have been used. The estimates show considerable changes in glaciation and surface river flow in the region for the medium and long-term future. To a greater degree, these changes will be shown in the form of reducing the glaciers’ areas and volumes and reducing river flow owing to the rise in temperature and increased precipitations.

Predicted assessment for glaciers

Glaciation change will depend on such factors as temperature rise, precipitation and structure of relief, which vary in the different basins. If we consider the evolution of glaciation for the last 50 years, and we compare data on the morphometry of glaciers of the USSR Catalogue published in 1965-1982 with data from ground observations and the ACF of glacial areas, then against the general background of a reduction in the number of glaciers, there were stationary indicators and some expansions (increasing linear dimensions, the “revival” of “dead” tongues). For the great bulk of glaciers, reduction indicators are characteristic: the disappearance of glaciers of 1 km², the reducing of ablation areas, the breaking up of large glaciers into separate inflows, the increase of moraine areas and natural glacier pollution (Agaltseva, 2002).

Forecasts by experts and scientists in Tajikistan show that by 2050, one thousand small glaciers will disappear in the country, the glaciation area will be reduced by 20%, and the ice volume will decrease by 25%. This will lead to a reduction in the glacier supply of rivers by 20-40%. The total flow of the Zeravshan, Kafarnigan, Vakhsh and Panj rivers will lower by 7%. The predictive increasing quantity of atmospheric precipitation by 14-
18% will not have a considerable influence on flow, as the most part, fallen precipitation will evaporate from surfaces of catchment areas.²

An expedition of Kazakh glaciologists that took place in summer 2005 confirmed this continuing reduction of glaciers in the Northern Tien Shan. Connecting this process with global climate warming, the expedition’s participants note that, if glaciers’ thawing rates persist, within the next 10-15 years the flow of mountain rivers will be reduced by double (Seversky, 2006). According to materials from the 13th Glaciologist Symposium (Materials of glaciologist researches, 2004) the available tendency may already lead to the disappearance of glaciers in the Southern Jungaria by the middle of the 21st century.

In general, according to experts’ assessments, the air temperature rise by on 1-2 °C will strengthen the process of glaciation degradation. During 1957-1980 the glaciers of the Aral Sea Basin lost 115,5 km³ of ice (about 104 km³ of water), which represented almost 20% of ice reserves for 1957. By 2000 the losses have totalled 14% of the reserves for 1957. By 2020-2025, the glaciers will lose no less than 10% of their initial volume (Agaltseva, 2002).

Predicted assessment for surface flow

Analysis of existing research shows different forecasts for the influence of climate change on river flow in Central Asia. Data from research studies varies from inconsiderable flow changes (2-7%) to considerable (10-40%) over the long-term future.

According to Agaltseva’s data (2002), calculations carried out on a mathematical model of the formation of mountain rivers flow at the

². Climate change - forecasts of Tajik experts. Dushanbe, 2002. Results of expeditions organised by the Executive Committee of the International Fund for Saving the Aral Sea (IFAS), the Regional Center of Hydrology (RCH) and the National Hydrometeorological Services (NHMS) of Tajikistan, 2005-2006.
realisation of various climate change scenarios allow us to assume that in the next 20-30 years, a considerable change of water resources should not be expected. However, as a result of climate warming there will be a reduction in average water consumption for the vegetative period. The possible flow changes of this period will be within natural variability: from +3 to -2. In particular, a considerable reduction in the flow of the Amu-Darya and Syr-Darya rivers in the next 20-30 years is not expected (Agaltseva, 2002).

Table 3. Expected change in water resources of the main rivers of the Aral Sea basin at realisation of various climate scenarios (in % from base rate)

<table>
<thead>
<tr>
<th>River</th>
<th>Base rate (km$^3$/year)</th>
<th>Climate scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ECHAM4</td>
</tr>
<tr>
<td>Syr-Darya</td>
<td>37.9</td>
<td>-2</td>
</tr>
<tr>
<td>Amu-Darya</td>
<td>78.5</td>
<td>-3</td>
</tr>
</tbody>
</table>

Source: Agaltseva, 2002

According to predicted assessments in the First National Report of the Republic of Tajikistan under the United Nations Framework Convention on Climate Change (2002), glacial supply of rivers in Tajikistan will be reduced by 20-40%, and the total flow of the Zeravshan, Kafirnigan, Vakhsh and Pyandj rivers will fall by 7% (an optimistic assessment). In the more remote future, the temperature rise by 3-4°C in comparison with that of the present will lead to considerable glaciation degradation, which will result in a catastrophic decline of the water content of rivers, by 30% or more. The same opinion is shared by some experts in Kazakhstan, who consider that within the next decades, owing to global climate warming, the water resources of Kazakhstan’s main rivers may be reduced by 20-40%.
Considering the fact that flow forecasts for the long-term future should be based on the above long-term climate forecasts which are characterised by their low reliability, it can be supposed that in the future, nature will give us many surprises, in particular regarding the change of hydrological regime in Central Asia’s rivers. However, in spite of forecasts on flow change, it must be remembered that the growth in water consumption in the region, linked with population growth and the intensive development of the countries’s economies, will reach 15-20% by 2025-2030.

**Socio-economic and ecological consequences of climate change in the region**

There are not many countries in the world that depend so much on each other as these five Central Asia countries. Water and power resources are one of the basic links of this region’s countries. The upstream countries have one of the world’s largest resources of fresh water, while the downstream countries have considerable mineral resources. And if the latter countries depend on their “upper” neighbours for the intensive irrigation needed for cotton growing, then the upstream countries depend on their “lower” neighbours to the same degree for power.

Natural flow resources in the Aral Sea Basin have already disappeared completely, and the region’s economy is developing in conditions of increasing water shortage. Their total use has now reached 130-150% in the Syr-Darya river basin and 100-110% in the Amu-Darya river basin (Kipshakbaev; Sokolov, 2002). Therefore, the impact of climate change will be especially marked in agriculture, and, particularly, in irrigated agriculture that consumes more than 90% of water resources of the region. Irrigated agriculture also provides about 30% of the GDP and ensures food security in the countries of the region. Cotton the dominant crop in irrigated agriculture, representing 20 to 40% of the exports of some countries of the region (Tajikistan, Turkmenistan and Uzbekistan). Besides the considerable economic benefit, irrigated agriculture also pro-
vides employment for much of the rural population. The lives of some 22 million people in Central Asia directly or indirectly depend on irrigated agriculture. The vulnerability of agriculture is also caused by an increase in natural hydrometeorological phenomena, the loss of water supply and the expansion of areas of soil degradation.

The negative consequences of climate change for hydro-power at the given stage are caused more by landslide and mud-flow phenomena than by a change in the hydrological regime of the rivers. So, the infrastructure for constructing Rogun HPP in Tajikistan was a victim of the flood in 1993. In the same river basin, in March 2002, owing to a complex influence of geodynamic and meteorological factors (storm precipitation), a large landslide massif was formed in the tail-water of Baipaza HPP. The increase in precipitation, especially in the areas subject to water erosion, has intensified the increase in silting of reservoirs. The formation and break-up of glacial lakes also constitute a potential threat to hydro-power infrastructures in this area. The reduced river flow that is expected over the mid- and long-term future will be unfavourable for hydro-power; it will also require reconstruction and change of the operating regime mode of waterworks facilities, the construction of additional reservoirs, protection facilities etc.

The influence of climate change is more obvious on the environment. More long, dry periods together with high spring and summer air temperatures can potentially increase the risk of processes of soil degradation and desertification. The anthropogenous influence occurring within climatic changes will aggravate these processes even more. In this region, more than 5 million hectares of irrigated land is in an unsatisfactory state as regards soil-reclamation, and is subject to salinization and waterlogging. There is uncontrolled felling of trees and shrubs in a zone of flow formation that is linked with hydro-power deficit in winter periods. The structure and efficiency of ecological systems are also subject to risk by the influence of global climate change. It is expected that in connection with reductions in river flow and temperature rise, together with an increasing anthropogenous load, the riparian woodlands will be degraded. In the case of frequent, pro-
longed drought, hygrophilous vegetation may be under threat. Warming will result not only in a change in diversity of flora and fauna species, but also in changes of biological interrelations in ecosystems. Against this background, new kinds of flora and fauna may also occur, species that are not characteristic to the region. Expected climate change may have a negative influence on the state of natural pastures and hayfields, which are a source of production of cheap food for animal husbandry.

Different disasters such as droughts, floods, mudflows, landslips, etc are increasing in the region owing to the climate changes that are occurring. Annual economic losses from such phenomena total hundreds of millions of dollars, not counting human lives. According to the Human Development Report on Central Asia (2005) the potential economic costs may reach 70% of the GDP of Tajikistan, 20% of Kyrgyzstan’s, with more moderate figures of 3-5% in Kazakhstan, Turkmenistan and Uzbekistan.

Owing to climate change occurring in the region, phenomena have been observed such as an increase in cardiovascular system pathologies, a growing influence of hypoxia in high-mountain areas, and outbreaks of epidemics of infectious-parasitic diseases connected with temperature rise and air humidity. In the case of floods, storm precipitation and the deterioration of the state of public water supply systems, together with a background of high temperatures, the risk of typhoid fever, paratyphoids, salmonellosis, dysentery, amebiasis, helminthiasis, etc. has increased (Kajumov; Makhmadaliev, 2002).

The above problems require urgent measures to be taken to adapt to climatic changes and to mitigate their influence in all Central Asia countries.

Measures for adaptation to climate change

Mitigating the influence of climate change requires a complex approach, including measures for reducing emissions of greenhouse gases and adaptation. One of the main measures in this plan is to reduce emis-
sions of greenhouse gases and to improve the state of natural carbon absorbers. All the countries are signatories of the UN Framework Convention on Climate Change, which came into force on 21 March, 1994. The ultimate aim of the convention is to stabilise the concentration of greenhouse gases in the atmosphere at such a level that would not represent a dangerous anthropogenic influence on climatic system. Within the framework of the aforementioned convention the countries of the region develop national programmes for reducing climate change and adapting to its consequences, as well as submitting information on an inventory of greenhouse gases to the convention secretariat.

Considerable emissions reductions in the atmosphere would be encouraged by giving priority to the use of renewable energy sources instead of fuels that are the main sources of air pollution. Within this plan, hydroresources (which have an effective potential of 460 billion in KW hours/year, exceeding the consumption of the Central Asia region by more than three times) are preferable. Up to 10% of this potential is used. Construction of the Rogun and Dashtijum HPPs in Tajikistan and Kambarta HPPs in Kyrgyzstan, with reservoirs that will enable the maximisation of flow regulation levels for the Amu-Darya and Syr-Darya for many years to come, and will provide a secure water supply, and may improve the situation in this sphere. Besides being an ecologically clean and cheap power supply, hydro-power is also important from the point of view of the sustainable use of natural resources in the long-term future, after oil and gas reserves (which are intensively used by some countries in the region for generating electric power) have been exhausted. The reservoirs of waterworks facilities, besides their reliable long-term and seasonal flow regulation maintenance, also promote the prevention of such extreme hydrological phenomena as flashing, mud-flows and flooding, and the mitigation of the consequences of drought.

Mitigating negative water-related consequences also requires a safe hydrometeorological monitoring system. After the collapse of the Soviet Union, the hydrometeorological network of the region declined. However,
since then adequate measures have been taken which have considerably improved the situation. At present in the region, thanks to financial support from the Swiss Agency for Development and Cooperation, the project “Swiss support to NHMS in the Aral Sea Basin” has been implemented, aimed at restoring hydrological and meteorological stations, improving the quality of forecasts and data exchange at national and regional levels, and also providing the necessary NHMS of CA countries with equipment and software. In 2007, the Executive Committee of IFAS and World Meteorological Organization commenced the project “Hydrological Cycle Observing System in the Aral Sea Basin” (Aral-HYCOS) which is also intended for strengthening the capacity of the NHMS of Central Asia in the sphere of water resources assessment and research into the global hydrological cycle. The project is supported by some donor agencies.

In conditions of climate change, there is a need for effective use of soil and water resources, with the minimisation of anthropogenous influence. This, first of all, concerns irrigated agriculture, and the need for the development of new ameliorative regimes, an increase in the efficiency of irrigation systems and introduction of progressive irrigation methods, encouraging water saving, and the optimising of an agricultural composition by moving from hygrophilous to more drought-resistant crops for reasons of food security. It would be promoted appreciably by the introduction of Integrated Water Resources Management (IWRM).

However, a primary factor in ensuring water security against the predictable reduction of river flow in Central Asia is undoubtedly the regulation of the use of water resources at the interstate level. Central Asia needs a new strategy of water distribution, to be developed taking into account the climatic changes occurring and development scenarios on a medium- and long-term basis and considering the interests of all the countries of the region. At present, water resources in the Central Asian part of the Aral Sea Basin are used on the basis of feasibility studies from the USSR period, adopted by agreements from the Post-Soviet period. In the new political and economic conditions, the interests of the countries of the region were
Impacts of climate change on water resources in Central Asia

divided. Tajikistan and Kyrgyzstan –where the main flow of the Aral Sea Basin (more than 80%) is formed– are interested in using the available water resources for power generation, but the downstream countries (Kazakhstan, Turkmenistan and Uzbekistan) intend to continue to use the same resources for irrigation. The situation is aggravated by the fact that the upstream countries are interested in the maximum water discharge in winter, when electricity needs are very high, while the downstream countries need the same maximum water discharge in the summer for irrigating land. All these gradually become a potential risk for starting conflict in the region.

Thus, it can be stated that the extent of the problems and tasks with respect to mitigating the influence of climate change is impressive and covers almost all the spheres of human life activity. Priority attention in the region should be paid to this problem, together with to the extensive drying-up of the Aral Sea. Mitigating and overcoming these crises will require the mobilisation of efforts by all stakeholders and more harmonious cooperation between the Central Asian countries. The difficulties of the last winter, followed by a drought-affected summer have shown again the necessity for valuable and effective cooperation in the region. Only together can we withstand all these threats.

**Bibliographical references**


KUZMICHENOK, V. A. Monitoring of water and snow-ice resources of Kyrgyzstan. (figures for the year 2006).


Impacts of climate change on water resources in Central Asia

