



Eurasian Development Bank

The Impact of Climate Change on Water Resources in Central Asia



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Abstract

Water shortages are considered to represent the main impediment to the development of Central Asian countries both under present-day conditions and for the future. The expected increase in water consumption is bound to stiffen competition for water both on regional and national levels between irrigation for farms, hydropower generation and other sectors of the Central Asian economy. Irrigation accounts for more than 90% of all water intake from the region's rivers. The pressing need to preserve food and energy security is set to boost water consumption even further, thereby aggravating frictions between the states in the region.

The problems associated with the exposure of the economy and the population to climate change are receiving increasingly close attention all over the world. Various scenarios regarding the consequences of climate change are being developed and scrutinised, and various methods are being proposed where it comes to addressing those consequences.

Intensive climate warming is being recorded throughout Central Asia, and the forecast for the region's water resources as a result of that warming suggests that none of the aforementioned scenarios envisages an increase in water resources. Calculations show that by 2050 the water runoff in the basins of the Amu Darya and the Syr Darya will dry up by 10 to 15 and by 6 to 10% respectively.

Central Asian states are seeking ways to prevent or mitigate economic damage as a result of contamination and depletion of water resources.

The states of the Aral Sea basin all face the task of enhancing more effective and economical use of water, management of water demand, and finding a compromise between the interests of upstream and downstream states. Moreover, there is the need to serve the requirements of both water users and ecosystems.

A key purpose of a common integrated water resources management (IWRM) in the Aral Sea basin is a prerequisite to successful adaptation to climate change, efficient use and protection of water resources, switching to water-saving technology first and foremost in the irrigation of farmland, as well as expansion of international cooperation in the use of hydropower resources on both regional and national levels.

The development and implementation of IWRM as a key tool is expected to ensure reliable and efficient national and regional water resources management in relation to current and pending climatic changes. It will help improve the mechanisms of rationalising the distribution of water resources, controlling demand for water, environmental protection, the quality of water and handling crisis situations.

List of abbreviations

CA – Central Asia

CDM – clean development mechanism

ECE – Economic Commission for Europe

ES – executive summaries

GDP – gross domestic product

GHG – greenhouse gases

HPP – hydropower plant

IFAS EC – Executive Committee of the International Fund for Saving the Aral Sea

IFAS – International Fund for Saving the Aral Sea

IPCC – Intergovernmental Panel on Climate Change

IWRM – integrated water resources management

NGO – non-governmental organisation

NIS – national innovation systems

OECD – Organisation for Economic Cooperation and Development

R&D – research and development

RCG – Regional Hydrology Centre

TR – technical report

UNEP – United Nations Environment Programme

UNESCO – United Nations Educational, Scientific and Cultural Organisation

WMO – World Meteorological Organisation

1. Introduction

The world community has posted significant progress in dealing with a new global problem which is climate change. The initial studies and joint measures to implement as a response to this global challenge have received international legal support with the adoption of the UN Framework Convention on Climate Change. It was first open to signatories at the Earth Summit in Rio de Janeiro on May 9, 1992, and 154 countries including the entire European Union joined it. On March 21, 1994, the Convention came into force and at present 189 countries are participating in it.

The objective of the Convention is to control anthropogenic emissions in the form of greenhouse gases (GHG). The Convention imposes different obligations for its member countries depending on their potential, their economic structure and their available resources.

Measures aimed at mitigating the consequences of climate change include adaptation to an increase in the average temperature, a seasonal cycle shift, and an increase in the frequency of extreme meteorological incidents. The question is not whether it is necessary to adapt to climate change, but how to adapt. In order to comprehend long-term scenarios, climate model projections have been built. Although these scenarios have not yet been conceived in adequate detail or on national levels, they have proven to be instrumental to identify the main consequences of climate change, to determine forecasts and to set priorities in terms of needs for adaptation.

The Convention has provided a solid basis for coordinated international initiatives. However, until the Kyoto Protocol of 1997 came into force, obligations for parties to the Convention were not defined in the form of clear targets within clearly indicated periods of time. The Protocol has not only formulated such goals but it also offers innovative mechanisms in order to achieve them in the form of joint projects, «clean» development policies and technologies and a regulated market for trade in emission quotas. To some extent, such mechanisms had been applied before the Protocol came into effect. But this document is a pivotal step towards a global system of response to climate change. What is just as important is that can promote new technology, in particular in the domains of energy and transportation, and help many countries to transform their economies into models that can cope with the XXI century and secure their sustainable development. In this sense, the Protocol can be seen as a powerful tool. Bearing in mind that the Convention calls for consistent steps in the direction of the ultimate goal, the Protocol provides obligations for parties that can be periodically revised.

Climate change poses a serious threat to the environment. Its most immediate impact is the so-called greenhouse effect. The main consequence of climate change is an increase in global surface temperature, triggering changes in precipitation levels and the hydrological composure of water bodies, and thereby in the quantity and quality of water resources. Compared with the second half of the XIX century, the global surface temperature has increased by 0.3–0.6°C. As a result, just to name one example, glaciers in mountainous areas are set to shrink, which in turn will result in the lowering of the snow line. This is also bound to affect the water intake and outflow of rivers.

The effect of climate change on water resources is particularly manifest in Central Asia. In this region, water resources are crucial for a wide range of issues related to national and regional security, since water is being consumed by all sectors of the regional economy. The biggest consumer of water is farming irrigation which accounts for one-third of gross domestic product and for over two-thirds of employment. Irrigation consumes more than 90% of the available water resources in the Aral Sea basin. Water resources are also of utmost importance to energy supplies to the region and account for 27.3% of its power generating capacity. In Tajikistan and Kyrgyzstan, this percentage exceeds 90%, thereby indicating that their economies all but entirely depend on the availability of water resources for their daily life. Therefore, any change affecting water resources in Central Asia is bound to have a profound impact on these countries' economies and their social and socioeconomic development.

1. Introduction

Central Asian countries share rivers that cross their borders and any change in the use of water inevitably cuts into the interests of others. Tajikistan and Kyrgyzstan, on the territories of which originates more than 80% of the water that ultimately flows into the Aral Sea, are more interested in using the available water resources for hydroelectric generation, whereas countries further downstream, meaning Kazakhstan, Turkmenistan and Uzbekistan, demand those resources for irrigation. Upstream countries have interest in discharging maximum volumes of water in winter time, when power shortages occur, while downstream countries need an optimal discharge in summer for irrigation.

This situation is even further aggravated by increasing water consumption due to growth in population and rapid economic development of the countries in the region, combined with declining inflows of water in the near future.

The melting of glaciers is poised to bring additional risks for the region's sustainable development and food security. Rapid glacier retreat threatens Central Asian countries with floods in the short run and with water shortages in the longer run.

Assessing the current state of the region's water resources taking the ongoing climate change into account, while identifying the underlying trends, provides a theoretical and practical outline for sustainable water resources management in Central Asia. The task of developing a modern, integrated system of water resources management in Central Asia calls for cooperation based on a common approach.

Considering the special role of water resources in socioeconomic development of Central Asian countries, EC IFAS and the Regional Hydrology Centre (RHC) with the technical assistance of the EDB prepared a report on the core consequences of climate change on the region's water resources. These institutions also provided an assessment of the exposure of water resources to the effects of their cross-border use.

The Bank aims to support states interested in addressing cross-border environmental problems and offers technical assistance in this domain. Related information can be found in this publication and on the Bank's official website www.eabr.org.

2. Changes in the hydrological cycle of the Aral Sea Basin

The Earth's climatic changes, and the threats associated with this change are being discussed in a number of international reports. Climate change is a complex problem stretching over a number of different disciplines. It requires an integrated approach based on the principles of sustainable development with an emphasis on changes in consumption and supply patterns. The effect on climatic change on communities and on natural ecosystems is becoming more and more dramatic. While it is widely accepted that certain climatic changes are inevitable, there grows recognition that joint efforts could help preventing many of its negative effects. Such efforts must be undertaken first of all in key areas, including energy efficiency, transportation, protection of water resources and biodiversity and renewable energy resources.

One of the most imposing problems in Central Asia is the increasing shortage of water caused by desertification and the rapid melting of glaciers in the mountains. The melting glaciers aggravate a large number of problems including the threat to food security. As Sirodzhinin Aslov, the representative of Tajikistan in the United Nations, comments: «Glaciers are melting, desertification is on the increase, rivers vanish, and the Aral Sea degrades. This is an environmental crisis – not of a regional but of a global order». Losses in the order of billions of dollars each year are the result of the region's ecosystem's overall degradation.

The Aral Sea is a major-size inland water body. It is located in one of Central Asia's desert zones, which consists of the Turanskaya plain on the eastern edge of the Ustyurt plateau. The Aral Sea is fed by two main Central Asian rivers, the Amu Darya and the Syr Darya. Their use for irrigation goes back to a long tradition. Virtually all rivers that flow into the Aral Sea and supply it with water cross international borders.

The Amu Darya flows through the basins of Surkhan Darya, Sherabad, Kashka Darya and Zarafshan. The basins of Kashka Darya and Sherabad are within the borders of Uzbekistan. The Amu Darya has most of its sources in Tajikistan.

The basin of the Syr Darya stretches over Kyrgyzstan, Uzbekistan, Tajikistan and Kazakhstan. The river's water feed comes mainly from Kyrgyzstan, where its tributary the Naryn contributes more than 74% to its water, whereas 14% of the water comes from Uzbekistan, 3% from Tajikistan and 9% from the Arys and Keles tributaries which originate on the territory of Kazakhstan.

The main watersheds of the Amu Darya and the Syr Darya are located in mountainous areas. The main origin of the water for the rivers and most of their tributaries comes from melting snow, while lesser volumes are provided from glaciers and rain. Depending on the level of which the watershed is situated, and the quantity and timing of precipitation, its share in water provisions for the river can significantly vary, thereby affecting runoff conditions.

The Syr Darya's runoff is located in Kyrgyzstan. It roughly consists of two phases, which are characteristic to conditions in the type of mountainscape the main range, Tien Shan, consists of: a sequence of seasonal floods which take place in spring and summer and lowering water levels during the autumn and the winter. Floods are at their peaks from April to June due to melting mountain snow and from July to September due to melting glaciers and patches of snow.

The hydrographic curve in the rivers that flow down from the mountains bear a feature which is special in regard to runoff fluctuations over the year and even within a single day. Thus, during the grain growing season, the river's water runoff accounts for 74% of the annual volume, while the remaining 26% is discharged during the autumn and the winter through to early spring.

Kyrgyzstan consumes 20 to 25% of its river water supplies while the remaining volume flows into other countries further downstream. Studies on the conditions of runoff peaks of Kyrgyzstan's rivers demonstrate that they can exceed average volumes to the following extents:

2. Changes in the hydrological cycle of the Aral Sea Basin

- a) by 2 to 3 times in the event of unusually high temperatures or of heavy precipitation;
- b) by 5 times in cases of mudflows caused by a combination of melting snow and heavy rainfall;
- c) by 7 to 10 times in the event of a lake burst, which can go up to 100 times when the Adygine basin breaks through its barriers and up to 500 times when it concerns the Yaschinkul or the Isfairam Say reservoir.

In all of Kyrgyzstan's rivers, water levels are down during the colder season when melting volumes are on the decline and the water runoff is mainly fed by groundwater. Low water levels are characterised by steady runoff declines until the seasonal floods start, as reflected in a groundwater depletion curve. The lowest runoff is registered just before the seasonal floods which take place in March and April.

Kyrgyzstan has 1923 lakes with a total water surface of 6840 km². The largest lakes are Issyk Kul, Son Kul and Chatyr Kul. Freshwater reserves held by these lakes amount to an estimated 1.745 km³. Kyrgyzstan's main lakes account for more than 55% of the total water surface of all the lakes in Central Asia. In the middle of the XIX century, the water level of Issyk Kul dropped by about 12 m and the water basin became locked. According to data from measurements, since 1927 the water level dropped by another 3.2 m. The decline of the water level took place at high speed in particular between the 1950s and 1970s, during which the coast line advanced at a rate of 20 m per annum. Water supply calculations for periods varying from one year to several decades all show a negative balance, meaning that the water level has kept dropping. The decline is mainly due to increased evaporation of the lake's surface waters as a result of increased temperatures. The average annual runoff of Kyrgyzstan's rivers between 1973 and 2000 increased from 48.9 to 59.9 km³.

The western and northwestern parts of the Syr Darya and Amu Darya basins, from the foothills of the Pamir–Alay and the Tien Shan into the plains, are located in Uzbekistan. This explains the relatively thin river water flows in Uzbekistan as compared to those in Tajikistan and Kyrgyzstan. Uzbekistan has more than 17700 natural waterways, most of which have a length of less than 10 km. Uzbekistan also has in the order of 505 lakes, mainly small ones with a water surface of less than one km². To date, 53 water storage reservoirs have been built in the country, mainly for irrigation purposes. Uzbekistan and other Central Asian countries are confronted with the need to find solutions to the problems of water shortages and the depletion and pollution of water resources. Measures are required to prevent and/or mitigate the impact of such problems.

Water shortages are seen as the main prohibiting factor to both the present-day and the future development of Uzbekistan. Uzbekistan has 525 small glaciers covering a total area of 154.2 km², the average surface of one glacier being 0.293 km². They are located upstream the Surkhan Darya, the Kashka Darya and the Pskem. Virtually all water resources of the region are fed by snow and glaciers located in Kyrgyzstan and Tajikistan, while irrigated farmland is concentrated in the densely populated valleys where the Amu Darya and the Syr Darya flow into Uzbekistan, Kazakhstan and Turkmenistan. The countries located downstream the Syr Darya and the Amu Darya face water shortages which affect their socioeconomic development. To date, many periodical measurements of water supplies in Uzbekistan fail to show an overall trend indicating depletion. Any expected changes in natural water supplies will mainly be determined by changes in the climate pattern.

The average year-on-year runoff in the Syr Darya–Aral basin in Kazakhstan, measured in terms of total water resources in natural conditions, used to be 26.1 km³ per annum, consisting of 3.5 km³ supplied from Kazakh territory and 22.6 km³ coming from Uzbekistan and Kyrgyzstan.

Between 1965 and 1985, a number of reservoirs were built in the Syr Darya basin with the purpose to regulate water supplies over periods of several years. They included the Toktobulskoye reservoir in Kyrgyzstan, the Shardarinskoye reservoir in Kazakhstan, the Kairakkuumskoye reservoir in Tajikistan and the Charvaskoye and Andizhanskoye reservoirs in Uzbekistan.

The Kyzylordinskaya, Kyzylkumskaya and Kazalinskaya irrigation systems were built to ensure regular runoff water use in Kazakhstan.

As a result of these measures, the runoff of the Syr Darya is now entirely under control. Downstream the river, excessive water intake has resulted in a dramatic decrease in water flows with disastrous consequences for the Aral region. Under sustainable water consumption conditions, the Syr Darya inflow into Kazakhstan amounts to 14.5 km³ per annum on total resources of 18 km³ per annum. This means that the natural pattern of river flows in Kazakhstan is completely out of balance.

Until 1990, the Toktogulskoye reservoir was mainly used for irrigation. Water used from Toktogulskoye in spring and summer represented 75% of its total annual discharge. In the mid-1990s, the pattern of discharging water from Toktogulskoye was drastically changed. Over the last decade, main water discharges of up to 60% of the annual amount took place in winter in order to keep domestic power supplies going. As a result, the annual breakdown of water runoff in the Syr Darya has changed dramatically: instead of low water levels during the winter, winter floods occur, accompanied by ice jams. These in turn cause floods further downstream the Syr Darya, in the vicinity of Kyzylorda. The largest discharges from Toktogulskoye took place in the early 2000s.

Water supplies through the rivers that run into the Aral Sea heavily fluctuate within periods of two to five years. For example, the year 1969 was particularly wet in the Syr Darya basin in Kazakhstan.

Studies demonstrate that there is little difference between annual water throughflows in the first and the second half of the XX century. The sole exception is Lake Balkash, the inflow of which through its tributary rivers during the second half increased by 8%, mainly due to additional inflow of melting water from degrading glaciers.

The upstream part of the Amu Darya is located in the utmost southeast of the Central Asian region. Tajikistan's massive mountain ranges divide the country into several hydrographic basins in which the rivers Pyandzh, Vakhsh, Kafirnigan and Zeravshan originate.

The Amu Darya basin plays an exceptional role in solving the region's socioeconomic problems, as it contains about 60% of all its water resources and 70% of all its hydropower resources.

The watersheds of the country's rivers are located high up in the mountains, and their main sources are snow which accounts for 60–70%, glacier and ground water which together make 10–30%, and rainfall which contributes another 5%. In foothill watersheds, the share of snow drops to 40–50%, and the shares of ground water and rainfall increase to 40 and 15% respectively.

A higher water content is observed in rivers the watersheds of which are exposed to moisture-bearing airflows. The largest annual runoff of about 45 to 50 litres per second per km² has been recorded in the basins of the tributaries of the Vakhsh, IKaratag, Sherkent and Kafirnigan rivers.

The annual runoff of river basins in the east of the Pamir varies from 2 litres/second km² in the Bartang river to 10 litres/second km² in the case of the Lyangar river.

The rivers that flow from the western slopes of the Academy of Sciences mountain range, the Yzagulem, the Vanch, the Obikhumbuand the Obikhingov and their respective tributaries, are more exposed to moisture-bearing airflows than others. The annual runoff of medium and small rivers on that location may be as high as 20–30 litres/second km². Small rivers in the foothills are essentially temporary streams originating from mudflows.

During a relatively long observation period of more than 50 years, no significant on-year or period-on-period for several years were noticed in the runoff of those rivers that were fed from glaciers and melting snow – meaning that there has been no change in the hydrological conditions of the main rivers in the Amu Darya basin.

2. Changes in the hydrological cycle of the Aral Sea Basin

Fluctuations of high and low volumes of river water distribute evenly across the territory in time series of two to three years.

Uninterrupted periods of highs and lows in terms of water volumes of 4 to 6 years were registered three times between the 1930s and 1960s, while the longest period of low water levels lasted 8 years.

A review of decade-to-decade runoff dynamics allows to identify an overall trend of decline in throughflows in rivers fed by glaciers and snow (11–14%) and in rivers fed by snow and rain (8–21%) between 1971 and 1980. Between 1981 and 1990, runoff decreased in rivers fed by glaciers and snow (1–11%) while it increased in rivers fed by snow and rain (6–25%).

An urgent task is set by the need for research, which is also of major practical importance to the region, after the effects of climatic factors on the generation of water resources in Central Asia and on the consequences for their annual distribution. As part of such an effort, corrective measures aimed at ensuring sustainable use of water given changes in the climate should be proposed.

3. Atmospheric precipitation and temperature changes in the Aral Sea Basin

With an immense surface stretching from 35–55 degrees in northern latitude and 50–85 degrees in eastern longitude and orographic complexity featuring vast plains in the north and west and high mountain ridges to the southeast and the east. Climatic conditions vary from region to region, even though they have one thing in common: the climate is highly continental with extremely varying temperatures, and scant precipitation throughout the area. Steppes dominate the northern plains of Central Asia, while the southern ones mainly consist of desert land.

Three basic types of climate zones occur in the region:

- 1) temperate climate zone north of 41–42 degrees latitude;
- 2) arid subtropical climate zone south of 41–42 degrees latitude;
- 3) mountain climate zones in the Tien Shan, Pamir–Alay and Kopetdag zones, subdivided into:
 - a) foothill zones of 0.2 to 1.2 km above sea level;
 - b) mid–mountain zones of 1.2 to 2.2 km above sea level;
 - c) mountain zones of 2.2 to 3.5 km above sea level;
 - d) eternal snow zones above 3.5 km above sea level.

Systematic climate monitoring has been carried out in Central Asia since the end of the XIX century. However, most stations located in the mountains were opened at a later stage, in the first half of the XX century. The largest number of stations worked in the 1980s, after which their overall number was reduced by one–third for economic reasons while the number of mountain stations was cut three times.

According to data resulting from observations, the main reason for the climate change in Central Asia is a considerable increase in air temperature close to the surface. Country–wise, increases in average temperatures over ten–year periods in various Central Asian states over varying periods of time have been the following:

- Uzbekistan (1950–2005): 0.29°C;
- Kazakhstan (1936–2005): 0.26°C;
- Turkmenistan (1961–1995): 0.18°C;
- Tajikistan (1940–2005): 0.10°C;
- Kyrgyzstan (1883–2005): 0.08°C;

The table shows that the increase in temperature on the territory of Central Asia was uneven. A more rapid pace of annual rise in air temperature was registered in the plains, whereas in mountainous areas the increase was less, and in some cases even cooling was registered. Thus, in Kyrgyzstan the entire territory of which is classified as mountain land, the average pace of warming has been the slowest in all of Central Asia. In high mountain zones in Tajikistan at heights exceeding 2500 m, temperatures rose only in April, November and December. Cooling was also observed in some lowland districts such as the valley of lake Bulinkul, in Tajikistan, where the average temperature between 1940 and 2005 dropped by 1.1°C, which can be explained by special climatic conditions in the eastern Pamir.

3. Precipitation and changes in air temperature in the Aral Sea Basin

In most parts of Central Asia the pace of warming has been faster in winter than in summer. Thus, in Kazakhstan winter temperature has risen by 0.44°C over each period of 10 years whereas summer temperatures rose by 0.14°C per decade on average. In Kyrgyzstan, winter temperatures have increased by 0.03°C per ten years. In Tajikistan, winter temperatures have risen by 1.3 to 3°C between 1940 and 2005. In Turkmenistan, by contrast, warming during winters has stood at 0.1°C each 10 years as compared with a rise of 0.2°C in other seasons.

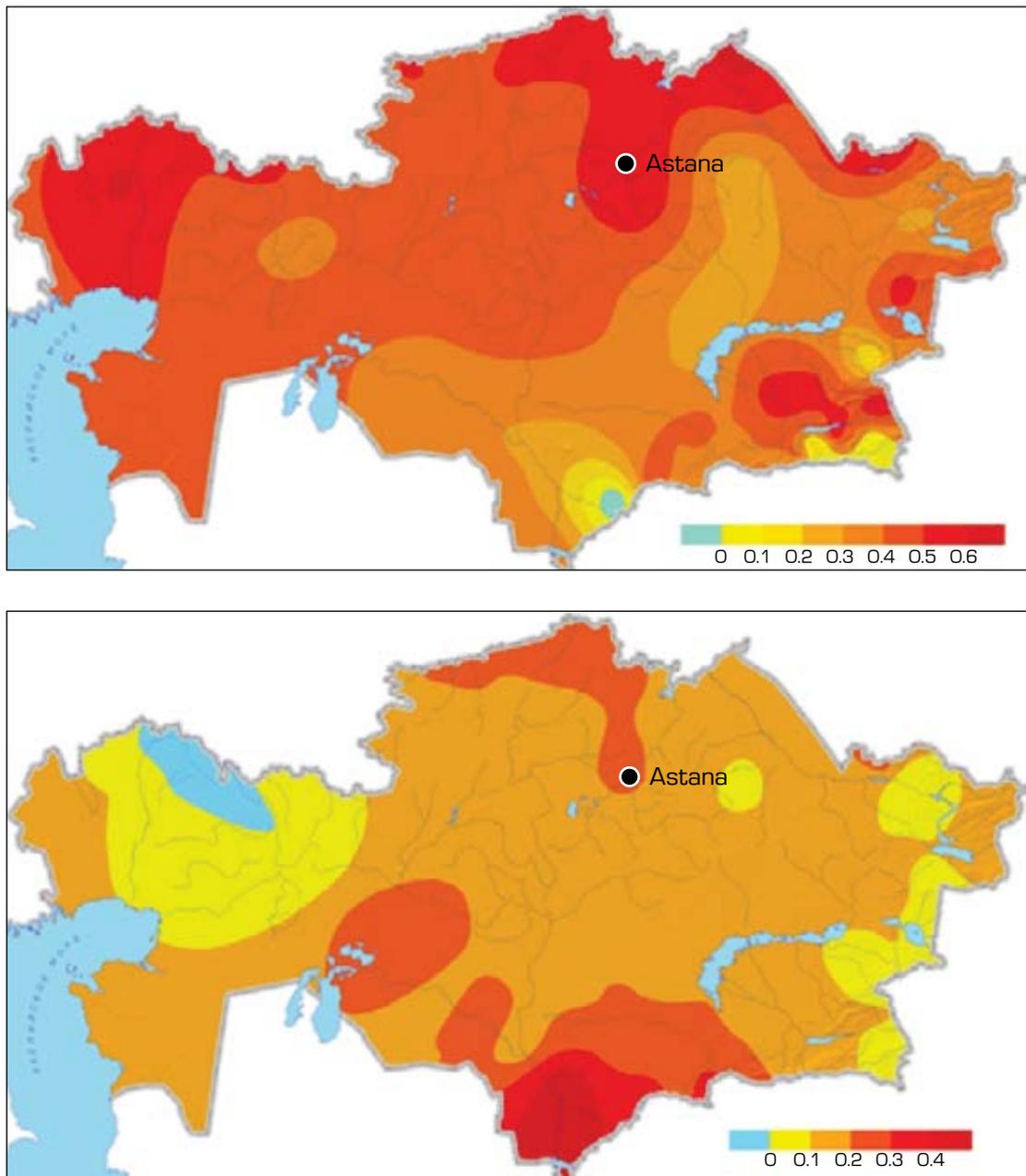


Figure 3.1. Spatial distribution of the near-surface air temperature linear trend ratio in winter (a) and summer (b) (in $^{\circ}\text{C}/10$ years) in Kazakhstan in 1936–2005

The overall increase in minimum temperature was larger than the increase in minimum temperatures. Thus, in Uzbekistan since 1951 decade-wise rise in maximum temperatures stood at 0.22°C against minimum temperatures at 0.36 degrees. The only exception has been the Aral Sea retreat zone where the pace of increase in maximum temperatures has been very fast, while minimum temperatures have been left unchanged, all due to the sea's shrinking waterbed.

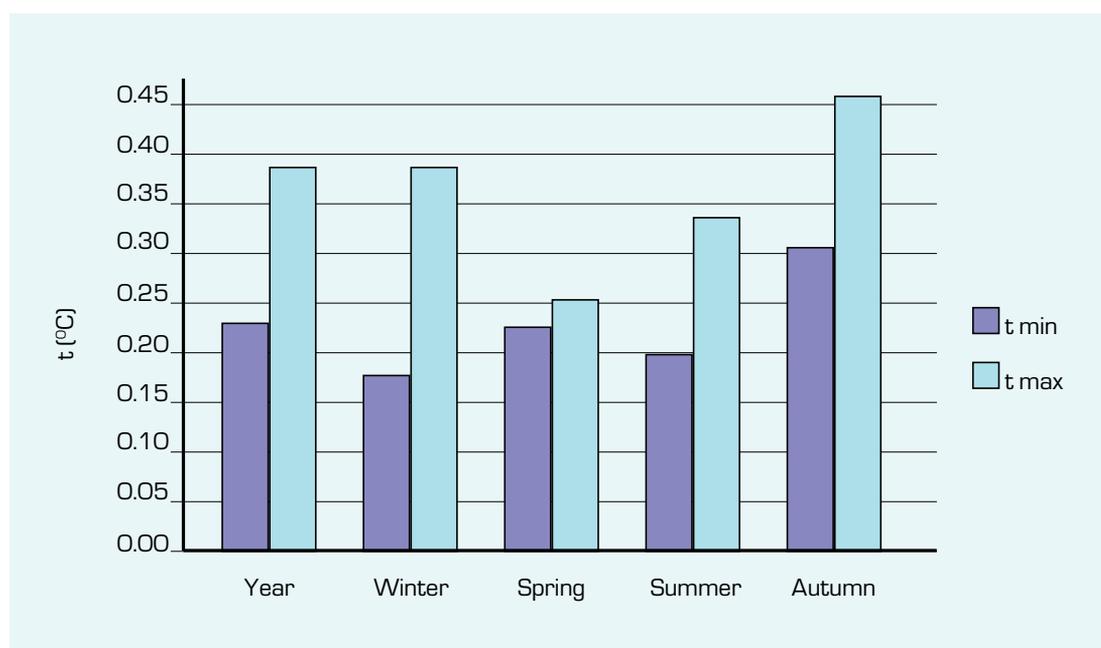


Figure 3.2. Average pace of increase in maximum and minimum air temperatures in Uzbekistan ($\Delta T/10$ years) since 1951

Changes in precipitation in Central Asia have shown uneven territorial and seasonal distribution as well. Thus, winter precipitation has increased in most parts of Kazakhstan (see Figure 3.3). The higher increases were noted in the southern part of the Urals, the Yesil valley, the Kazakh highlands and the foothills of the mountains in southern Kazakhstan. A slight decrease in average annual precipitation was registered in Moyinkum desert and nearby Lake Zaysan. On the whole, the spatial division of winter precipitation is in line with annual precipitation trends. Changes in summer precipitation, in terms of both increases and decreases, have been insignificant throughout the country.

In northern regions in which an increase in winter precipitation was observed, precipitation reduced in summer.

The landscape of Kyrgyzstan with its complex orography has seen changes in precipitation have been diverse. In the northwest of the country, most annual precipitation trends were positive within the range of 0.05–1.7 mm/year, but highland areas showed negative trends in the order of 3 mm/year. Plains and foothills showed a slightly upward trend of 0.01–1.7 mm/year. In the southwest, all mountain ranges showed both positive and negative changes in precipitation, with the former reaching maximums of 3 mm/year in foothill zones against maximum negative extents of 3.2 mm in the high mountains such as the area where the Chaar Tash meteorological station is located, on the western slope of the Ferghana range. To the northeast, only the Chon-Ashuu avalanche registration station has registered a negative trend of 1.1 mm/year. All other meteorological stations have registered positive trends with the range between 0.2–3.3 mm/

3. Precipitation and changes in air temperature in the Aral Sea Basin

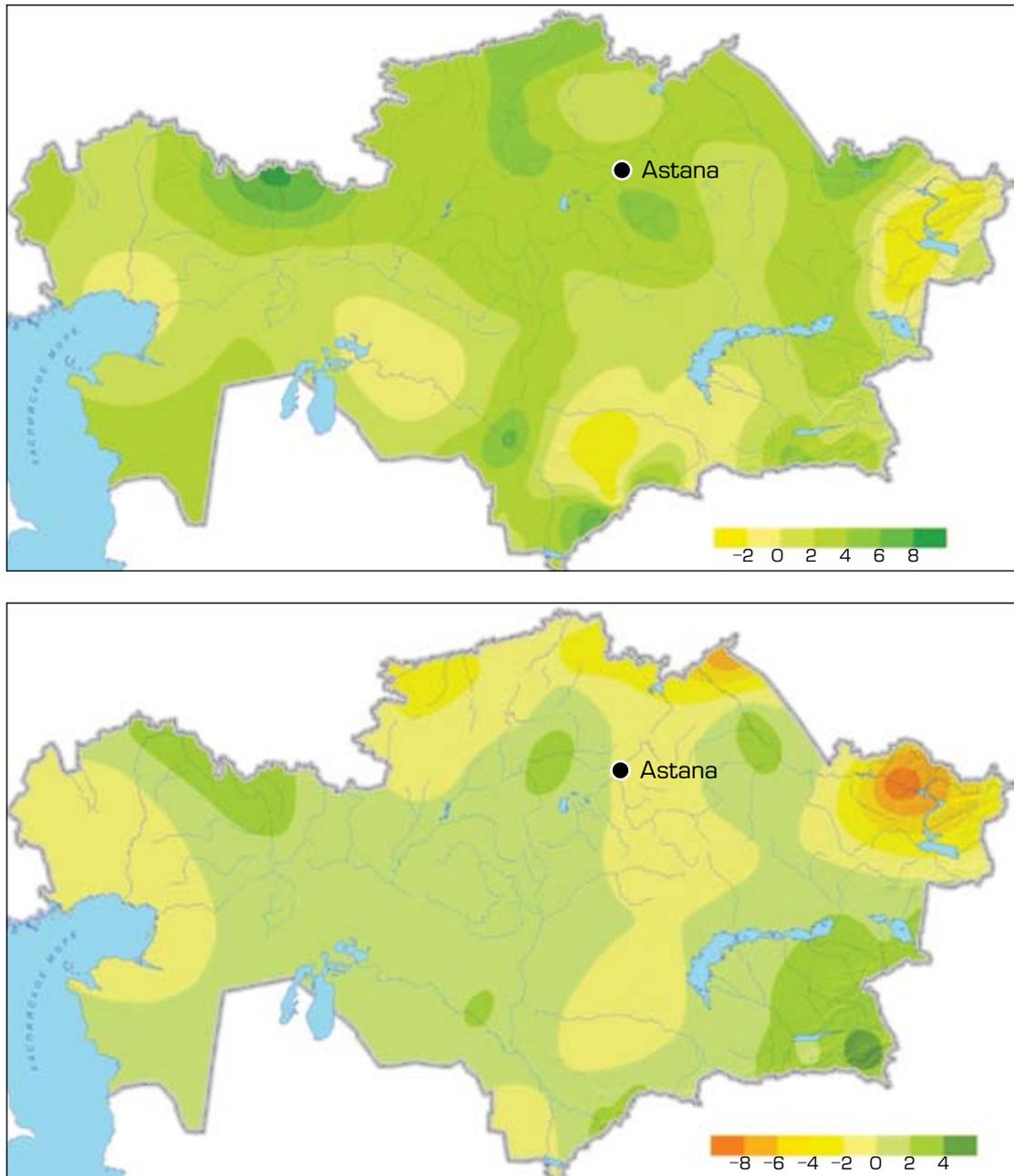
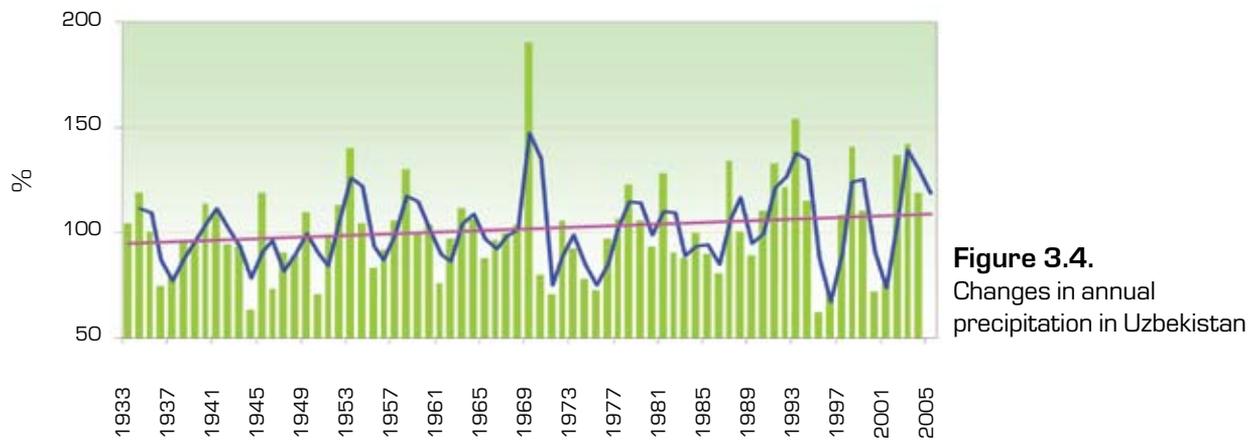


Figure 3.3. Spatial distribution of the total precipitation linear trend ratio in winter (a) and summer (b) (in mm/10 years) in Kazakhstan in 1936–2005

annum. In the central parts of the Tien Shan, most meteorological stations in both foothill and high mountain zones have registered negative trends within the range between 0.9 and 1.5 mm per year.

Considerable fluctuations of annual precipitation have been registered in Uzbekistan, with a slight overall upward trend (see Figure 3.4).

3. Precipitation and changes in air temperature in the Aral Sea Basin



Most parts of Tajikistan consist of mountainous areas showing very diverse patterns of precipitation division and long-term trends (see Figure 3.5). Thus, in the eastern Pamir, situated on a plateau of between 4000 and 6000 m above sea level, overall precipitation dropped by 5 to 10%, with the sharpest decrease of 44% having been registered in Murgab. A similar downward trend was observed in the country's southern lowlands such as Kurgan-Tyube and Shaartuz.



Annual precipitation has increased slightly by 8% in all parts of Tajikistan located at heights less than 2500 m above sea level, but has decreased by 3% in higher mountain zones. Precipitation tends to increase by 37 to up to 90% especially in summer and autumn in zones up to 2500 m above sea level, mainly due to heavy rains (see Figure 3.6).

3. Precipitation and changes in air temperature in the Aral Sea Basin

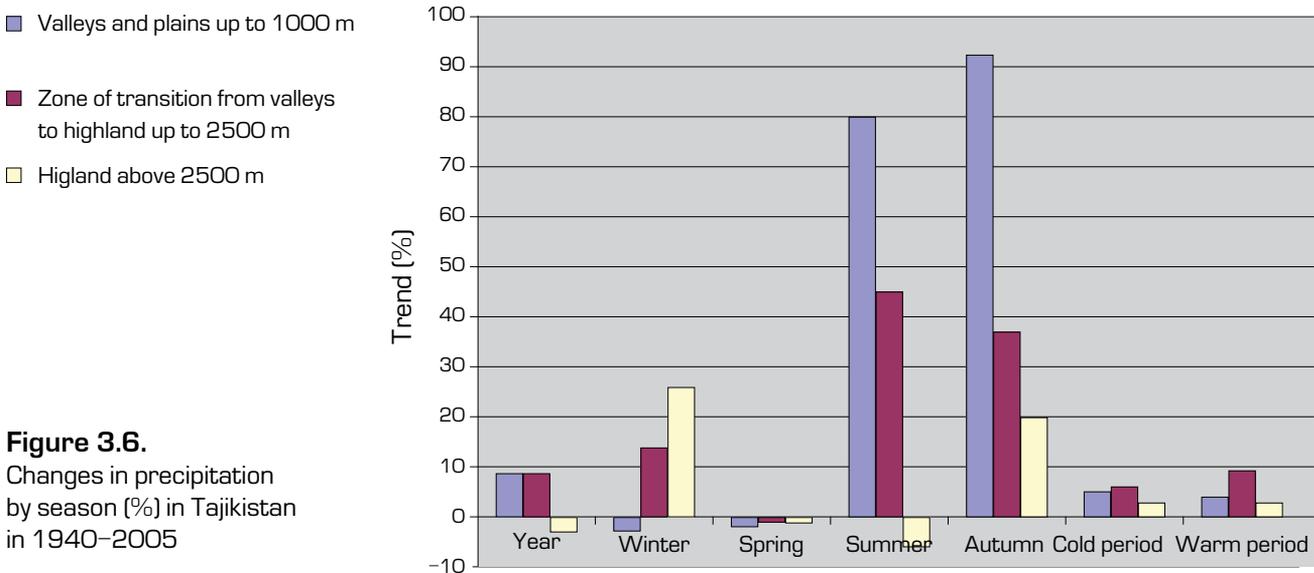
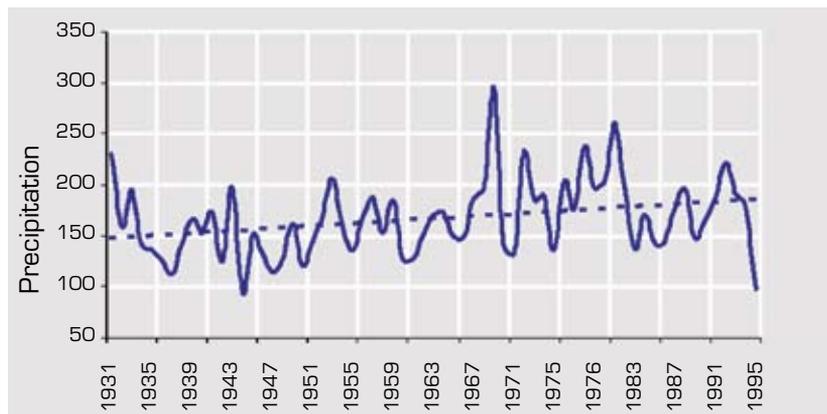


Figure 3.6. Changes in precipitation by season (%) in Tajikistan in 1940–2005

In Turkmenistan, an increase in precipitation throughout the year was recorded in 1931–1995, especially in winter and spring (by 1.6 and 1.3 mm/10 years, respectively). In summer time there was little or no change in precipitation. On average, annual precipitation in the country was increasing by 12 mm/10 year (see Figure 3.7).

Figure 3.7. Average multi-annual changes in precipitation in Turkmenistan (solid line) and the linear trend in 1931–1995



In many parts of Central Asia, fluctuations in intensity of precipitation are on the increase. This increasing irregularity with heavy rains being followed by droughts can worsen soil erosion in Central Asia. In summer, such precipitation patterns fail to wet the soil sufficiently, as it cannot absorb water quickly enough, and it evaporates partially as a result.

Considerable warming of the atmosphere in combination with a decrease or insufficient increase in precipitation results in increased aridity in desert and semi-desert areas in Central Asia. These trends have been confirmed by 60% of the monitoring stations in Kazakhstan. A study of adverse agrometeorological phenomena observed on affected farms in Kazakhstan has shown that the most common adverse trends between 2005 and 2007 were drought in the atmosphere and underground drought (60 and 10% respectively). A minor decrease in aridity is being observed only in certain foothill and mountain areas in which the increase in temperature has been insignificant.

4. The condition of glaciers

Warming in the Pamir, the Tien Shan, the Gissar–Alay and other mountain ranges has been following regional and global trends. Glaciers in the mountainous areas of Central Asia and Kazakhstan are the key long-term reserves of fresh water. They produce melting water in the hottest period of the year, when the reserves of seasonal snow are depleted, thereby compensating for shortages of irrigation water. However, these ice reserves are unstable. At present, retreating glaciers are being reported by experts all over the world. Whereas smaller glaciers disappear entirely, larger ones disintegrate.

Glaciers in Tajikistan play a key role in the water runoff of the Amu Darya and the Syr Darya, the largest rivers of Central Asia and the Aral Sea basin. In this arid region, any future consequences of climate change will tend to directly affect the volume of glaciers, the supplies of water to the rivers, and eventually the availability of water in countries and regions downstream.

Melting water from glaciers in Tajikistan contributes between 10 and 20% of the runoff in large rivers, and in particularly hot and dry years their contribution may rise to 70% (see Figure 3.1). Water is a key resource for agriculture, hydropower and the industries depending on them in Tajikistan. Moreover, the bulk of the water resources originating from Tajikistan is being consumed in countries further downstream.

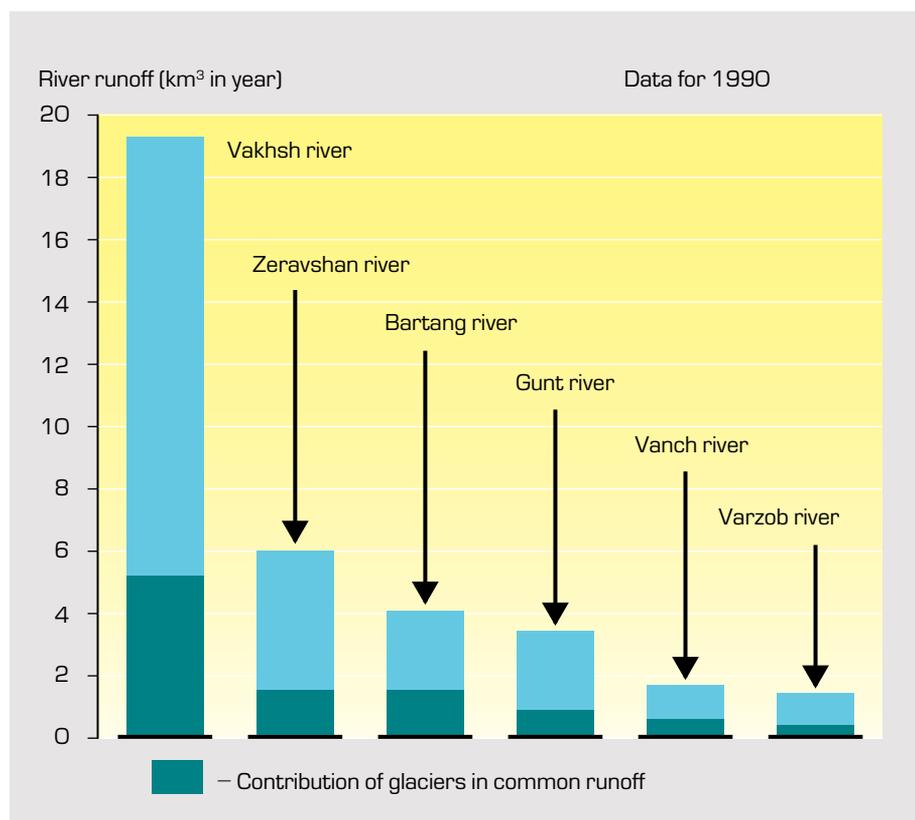


Figure 4.1. River runoff in a medium-water-content year and a share contributed by glaciers

An assessment of the effect of climate change on the glaciers in the Pamir–Alay shows that since 1930 when measurements started to provide the first data, the total area of glaciers in Tajikistan has shrunk by about one-third.

4. The condition of glaciers

The decline has been particularly dramatic in basins where large glaciers are located, such as the Bartang, the Muksu and the Fedchenko systems) in the central and southern parts of the area, and to lesser extents in basins containing smaller glaciers such as the Surkhan Darya and the Kashka Darya in the southern part of the Ferghana valley, in the north and the west.

During the XX century, glaciers in Tajikistan on the left bank of the Pyandzh river in Afghanistan dry up by 20 to 30 and by 50 to 70% respectively. In recent years, due to an increase in air temperature, surging glaciers have become more active.

While the total area covered by, and water reserves held by glaciers in Tajikistan may decrease by 15 to 20% and 80 to 100 km² respectively, from the condition they are in today, large glaciers and glacier systems will survive. The glacier-fed runoff of the Pyandzh, the Vaksh and the Amu Darya could initially increase as a result of intensified glacier melting, but this will be followed by a decline as a result of dwindling ice reserves. Any adverse change in the hydrological conditions of these rivers could pose a serious threat to certain exposed communities in particular and to the region in general (see Figure 4.2).

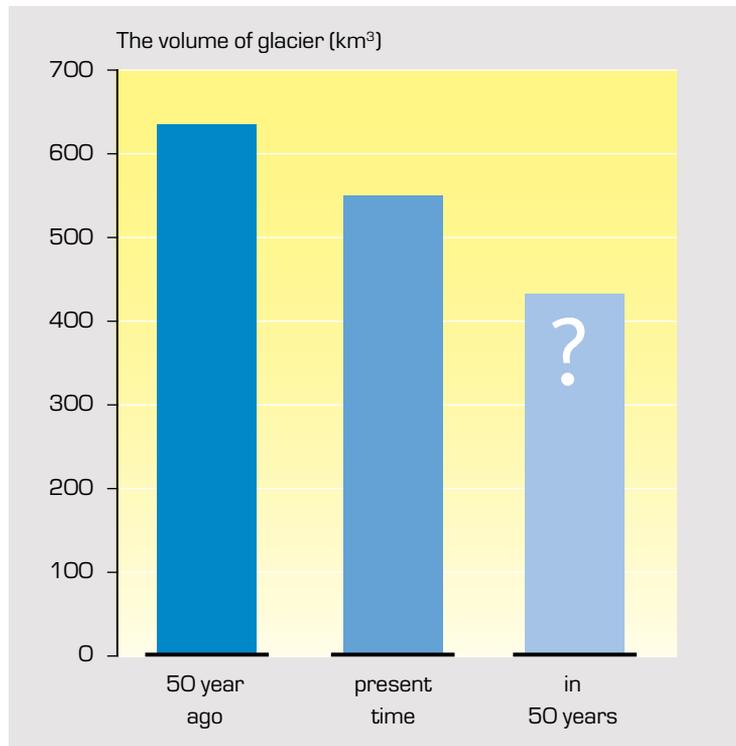


Figure 4.2.
Changes in the volume of glaciers in Tajikistan

Given the current pace of deglaciation, many small glaciers in Tajikistan are poised to disappear altogether in Tajikistan within the next 30 to 40 years to come. First of all, glacier degradation will affect the hydrological conditions of the Kafirnigan, the Karatag and the Obikhingov. During the next stage, a decrease in atmospheric precipitation may result in a decrease in surface runoff and thereby in the size of lakes' surfaces.

An assessment of changes in the glaciers of the Pskemsky range in the western Tien Shan has allowed to determine the current pace of deglaciation. During the past twenty years, glaciers in this area have been shrinking by 16.8%.

The calculation of the reaction by glaciers to climate change in the Gissar–Alay mountains in Uzbekistan that with a 50% decline in precipitation and a temperature rise of 3°C, the firn line is set to rise by 700 m and the area of glaciers and glacier-fed runoff is bound to decrease by 86 and 96% respectively.

For the purpose of assessing changes in glaciers in Kyrgyzstan, the following main hydrological basins were taken under observation: Lake Issyk Kul (I), the Chuy (II), the Talas (III), the Syr Darya (IV), the Syr Darya's tributaries of the northern slope of the Ferghana Valley (IVa), its tributary Naryn (IVb), its tributary Kara Darya (IVc), its tributaries from the southern slope of the Ferghana Valley (IVd), Lake Chatyr Kul (V), the Amu Darya (VI), the Tarim (VII), Lake Balkash (VIII) and the region as a whole (IX).

Glacier characteristics have been determined individually for each hydrological basin and the region as a whole. The results are summarised in Table 3.1 and Figure 4.3.

Basin	Number of glaciers	Area (km ²)	Volume (km ³)	Average thickness (m)
I	614 (97.3%)*	538.11 (84.6%)	24.224 (83.1%)	45.02
II	715 (94.8%)	582.12 (82.3%)	26.377 (80.4%)	45.31
III	177 (88.5%)	112.91 (72.7%)	4.643 (71.5%)	41.13
IV	2965 (95.2%)	1982.34 (84.1%)	100.973 (83.2%)	50.94
V	3 (100.0%)	2.61 (93.4%)	0.099 (92.6%)	37.75
VI	277 (99.6%)	604.36 (94.0%)	42.158 (93.5%)	69.76
VII	1693 (94.6%)	2991.83 (85.3%)	219.055 (84.8%)	73.22
VIII	1 (100.0%)	0.25 (82.3%)	0.008 (80.4%)	33.69
BK	6445 (95.2%)	6814.53 (85.1%)	417.537 (84.6%)	61.27
IVa	107 (89.9%)	39.41 (77.3%)	1.460 (76.1%)	37.04
IVb	1661 (94.2%)	1098.08 (81.2%)	55.657 (79.7%)	50.69
IVc	269 (91.2%)	74.18 (68.4%)	2.735 (67.1%)	36.87
IVd	928 (99.0%)	770.67 (91.0%)	41.122 (90.1%)	53.36

Table 4.1.
Main characteristics of glaciers in 2000

Note: * Change (%) as compared with the 1960s is given in brackets

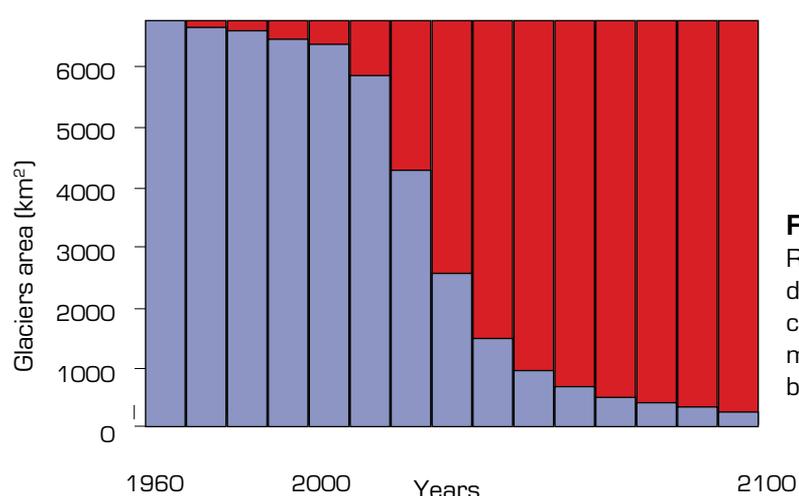


Figure 4.3
Ratio of remaining and defunct glaciers by decade, as per the model of the most probable climate change scenario ($dT=4.96^{\circ}C$, $m=0.96$). The remaining glaciers are marked blue and defunct glaciers red.

Between 1957 and 1980, glaciers in the Aral Sea basin have lost 115.5 km³ of ice, or in the order of 104 km³ of water, which was nearly 20% of all ice reserves as of 1957.

4. The condition of glaciers

The rivers that feed Lake Balkash originate from the glaciers of the northern and eastern Tien Shan and the Dzhungar Alatau.

In the Ili basin, glaciers dry up by 1254 km², or 36.6%, over the entire period, or by 25.1 km² on average per annum. In the entire Balkash basin, the decline amounted to 1498 km² over the period, or 30 km² (0.74%) per annum. Calculations show that this decrease in long-lasting reserves of ice and water may result in an increase of water inflow from rivers in excess of 10%.

To the opinion of experts, based on assessments of deglaciation during the second half of the XX century, global warming will result in the total disappearance of glaciers by the end of the XXI century. The studies also suggest that as consequence of deglaciation the Ili's runoff will decline at the rhythm of 2.26 km³ (11.6%) per annum, resulting in a decline of 2.54 km³ of water (10.5%) per annum into the Balkash basin.

Decreases in the water runoff in the Ili and Balkash basins take place at a pace determined by deglaciation. This decrease is in part offset by melting water from long lasting ice reserves. The overall decrease in river runoff is the result of two interconnected processes: loss of river runoff due to deglaciation and additional inflow of melt water from long-lasting ice reserves.

Deglaciation is set to reduce the river runoff in years when water contents are low by 25.4–27.9% and increase it in years when contents are high by 31.4–42.4%. Seasonal patterns of water distribution will also change significantly. The runoff is set to drop by two times in the months of July, August and September and subsequently all but double in April, May and June. This assessment of changes in the runoff and its annual time pattern was carried out through comparing the respective values in basins feeding on glacier water and those filled from other sources.

Calculations show that the global rise in air temperatures and continuing deglaciation are poised to pose additional threats. Reservoirs should be designed and constructed on mountain rivers, mainly for seasonal regulation of runoffs, together with protective hydraulic engineering installations.

Mountains and their foothills account for 15% of Kazakhstan's territory, and the areas they are located in are prone to excessive mudflows. In terms of mudflow activity, the Zailiysky Alatau ranks first in the Commonwealth of Independent States. According to Kazselezaschita, mudflows threaten 156 towns, including Almaty, and over 6000 industrial facilities. Mudflows originate from bursts in the surface releasing subterranean reserves under glaciers, as well as from heavy rainfall, powerful earthquakes, or human negligence. About 100 mudflows of varying origin were registered in less than 100 years, most of which had catastrophic dimensions and caused casualties.

Mudflows are basically triggered by geomorphologic, geological and climatic factors. A breakdown of the respective importance of those factors shows that the geomorphological factors which lead to the descendance of mudflows can be expected to subsist for some four million years to come, while geological factors are to remain in place for another century. However, mudflow activity on the northern slopes of the Zailiysky Alatau is determined by climatic factors.

Studies on climate in southern Kazakhstan as well as the geological structure of debris cones on the northern slopes of the Zailiysky Alatau demonstrate that during the Ice Age there was no mudflow activity whatsoever. Mudflow activity used to reach its peak at times air temperatures exceeded those in the time we live in by 2–3°C. It is most likely that a majority of the mudflow that have thrust billions of cubic m in rock debris down into the lowlands have taken decades to develop.

In the region under view, mudflows caused by heavy rainfall tend to occur at relatively high air temperatures. If the climate warms by 2–3°C, the upper boundaries of watersheds will rise

above 4000 m, and the watershed surfaces will increase by several times, meaning that all surfaces similar to those shown in Picture 3.4 will become potential sources of mudflows. The frequency of rains causing mudflows, the duration of mudflow risk time-spans, and the stretch of mudflow-generating areas will all increase. The catastrophic rain mudflows which used to occur in the XX century once in a hundred years will become annual routine.



Figure 4.4. A typical picture observed in the high-mountain zone of the Zailiysky Alatau after precipitation in summer. In the modern climatic conditions, heavy precipitation at elevations of 3400 m or higher mostly come in the form of snow or hail

Climate warming during the XX century has resulted in rapid deglaciation in the Tien Shan. This process was accompanied by the development of both surface and subterranean reservoirs in glacier systems. Each burst of such a reservoir resulted in catastrophic mudflows, such as the one on the northern slopes of the Zailiysky Alatau, which caused severe damage. At present, the most serious threat to Almaty is represented by a potential burst of Lake no.6 of the Manshuk Mametova glacier. A mudflow originating from it can cause damage in the order of \$100 million.

If the increase in temperature reaches 2–3°C, the steppe climate of the upper foothill zone of the Zailiysky Alatau will transform into a desert climate. These areas, currently covered with grass and bushes, will lose their loess cover and turn into wastelands (see Figure 3.5).

Virtually all liquid precipitation is due to result in mudflows, and mudflow sediments will cover the most productive soils in the plains under the mountain. A sharp increase in solid runoff of rivers flowing into the Ili will accelerate the silting process of the Kapchagay reservoir, and change the

4. The condition of glaciers

hydrological conditions in the Ili's delta and Lake Balkash. Farms subsisting on irrigation water will face serious problems, as the water is going to be unfit for irrigation and irrigation systems will be filled with debris.

The concept of protecting Almaty and other towns has so far relied on the notion that mudflows of disastrous proportions have been extremely rare. However, the catastrophic mudflows that occurred in the second half of the XX century have belied that notion. The outlook of a dramatic increase in mudflows through the first decades of the XXI century requires efforts to develop a new mudflow protection strategy.



Figure 4.5. Badland development in the Karaturuk basin (the Zailiysky Alatau)

A sharp increase in mudflow activity should be expected in mountainous areas of Central Asia in which glacier formation is still being observed these days. Sustainable development of Central Asia in the course of the XXI century will largely depend on whether or not adequate measures to prevent mudflows or at least mitigate their consequences will be carried out in a timely manner.

5. Changes in climate forecasting

Climate forecasting is one of the key tasks in developing climate change scenarios and taking the appropriate responsive measures to adapt to the new situation. It is in line with this general concept that statistical outlines of future climatic conditions and their variables over different periods of time is considered the crucial phase in a series of measures aimed at fending the exposure of various economic sectors to climate changes. In order to determine the level of that exposure, climate change scenarios have been developed.

The greenhouse gas emission scenarios included in the Special Report on Emissions Scenarios (SRES) offer a variety of different socioeconomic consequences resulting from various levels of future emissions of gases and aerosols. These SRES scenarios disregard any particular initiative relating to climate change or the probability of certain events. Each scenario is a quantitative assessment of one of the four «families» of different scenarios. Examples of illustrative descriptions of socioeconomic impacts among the six SRES scenarios are the following:

The **A1–scenario family** is characterised by rapid economic growth, a quick proliferation of new and efficient technologies, and a global population growth to 9 billion as of 2050 from where it gradually declines. This type of development is that of a more integrating world, in which income and life–style converge between regions, as extensive social and cultural interactions develop on a global level. There are three subdivisions to the scenarios based on their energy resources' main applications: fossil fuel (A1F1), non–fossil energy resources (A1T) and a spread of different energy resources (A1B). A spread would mean the end of overdependence on any single energy resource, provided energy saving technologies among industrial and end users will be applied at the same time and pace.

The **A2 scenario family** is that of a more divided world consisting of independently developing, self–reliant nations. Birth rates in various regions converge at a slow pace, and populations remain on the increase. Economic development is confined to regions, and technological changes and improvements in income per capita vary to larger proportions.

The **B1 scenario family** is characterised by a more integrated world with, as in the A1 model, a population reaching its peak by 2050 and from there on declining, and rapid economic growth with changes towards a service and information economy with the introduction of clean and resource–saving technologies. An emphasis is being laid on global solutions to economic, social and ecological safety and «justice», nonetheless in the absence of any specific initiatives regarding climatic conditions.

Like the A2 family, the **B2 scenario family** is characterised by an emphasis on local–scale rather than global solutions to economic, social and ecological safety. Global populations continue to increase but at slower pace than in the A2 model. B2 scenarios envisage intermediate levels of economic development and less rapid and more fragmented technological shifts than in A1 and B1. Like in B1, these scenarios have an emphasis on environmental protection and social justice, but with local and regional levels playing a key role.

According to the six scenarios given in the SRES, the forecasted CO₂ concentration in the atmosphere by 2100 will be 540 to 970 million⁻¹, as compared with 280 million⁻¹ in the pre–industrial era and 368 million⁻¹ in 2000 (see Figure 4.1).

5. Changes in climate forecasting

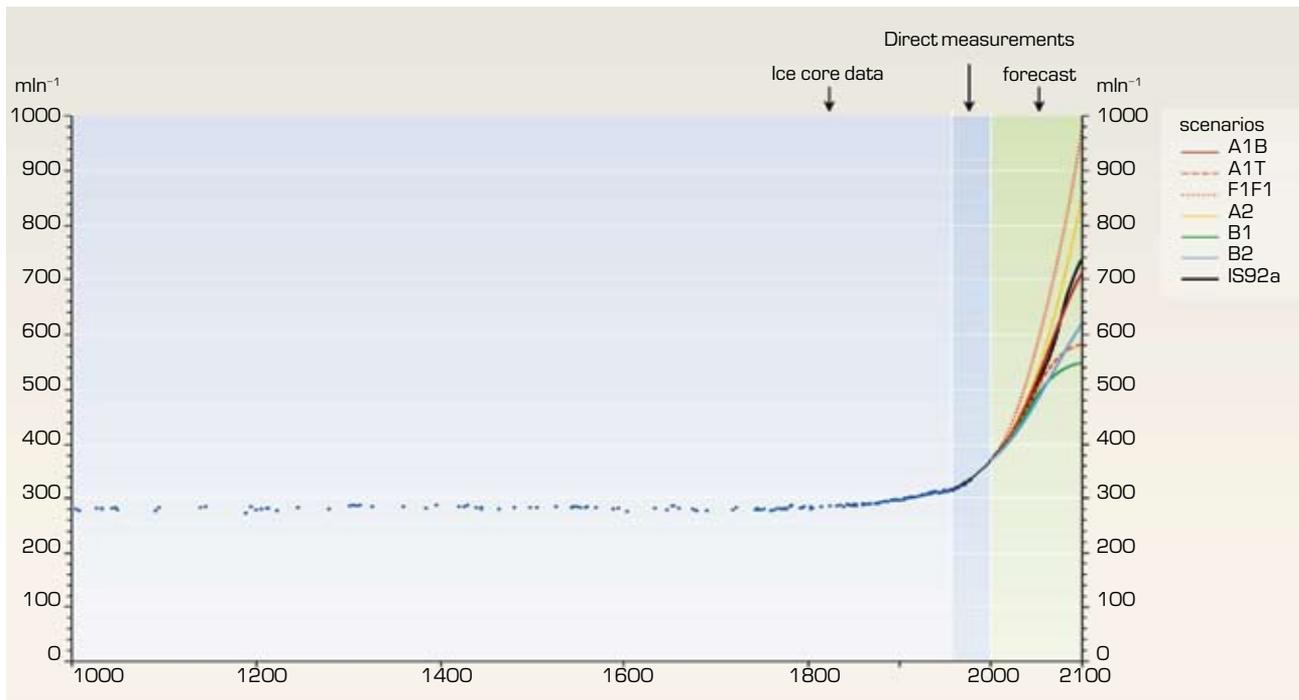


Figure 5.1. Atmospheric concentration of CO₂ in 1000–2000, calculated based on ice core analysis and direct atmospheric measurements done in the past decades. Forecasted CO₂ concentrations for 2000–2100 are based on the six illustrative scenarios given in SRES and IS92a (for comparison with the Second Assessment Report)

6. Assessment of changes in water resources of the main cross-border rivers in Central Asia

The combination of rapid urban development, growing water consumption in agriculture and industry and contamination of water resources has resulted in a decrease of water provisions per capita. These problems are further aggravated by climate change and extreme weather conditions. Land and water are critical resources, and lack of availability of either of them can lead to social conflicts. Water balance models suggest that supplies of water in terms of both quantity and quality are set to deteriorate. Higher temperatures result in the depletion of surface water resources and droughts. Changes in river and lake runoffs affect the productivity of hydropower plants. Droughts, floods and other extremities may damage water distribution infrastructure, while excessive precipitation may wash away nutrients from soils and cause erosion.

To study the sensitivity of water resources in Central Asia to anthropogenic climate change, existing forecast models for water runoffs have been used.

The main input data for hydrogenic runoff modelling are daily precipitation and average daily air temperatures measured by meteorological stations located within or close to the basin.

In addition, in order to assess changes in water resources in certain countries, the water balance equation method was used. This equation uses air temperature and precipitation data calculated in global and regional climate models, and evaporation data calculated through increases in air temperature. The models have been primarily adapted for assessing sensitivity of water resources with the use of potential anthropogenic climate change scenarios.

Anthropogenic climate change has been used as a parameter according to scenarios A2 and B2 in the aforementioned series, to build these scenarios. Versions 2.4 (Turkmenistan) and 4.1 (Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan) from the complex applications from the Model of the Assessment of Greenhouse-gas Induced Climate Change / Scenario Generator (MAGICC/SCHENGEN) were used. The designs for these applications were commissioned by the IPCC with the purpose, among others, of assessing sensitivity levels. Both scenarios have been built in since their levels of probability are equal and the effect of climate change on water resources should be forecasted implying both of them.

In **Kazakhstan**, runoff modelling was done for all major rivers, with results indicating that:

1. If anthropogenic climate change as a result of greenhouse gas emissions through the upcoming 30 years follows scenario A2, the water resources in the mountain areas' basins are to increase within the range between 0.8–4.5% to one between 14–22.5%, while at the same time the water resources in the lowlands will decrease by 7–10.3%.
2. According to scenario B2, during the upcoming 30 years the runoff in mountain areas will decrease within the range between 2.5–9.3% and 12.3%. In the Arys basin, the decrease by 2%. Scenario B2 is more «pessimistic» in regard to mountainous areas but more «optimistic» in respect to the lowlands where a decrease in resources will be limited to the range between 6 and 6.8%.
3. If the climate change pattern is to follow scenario A2 over the upcoming 50 years, water resources in Kazakhstan's mountainous basins will increase by 1.3–12.7% on average. In the river basins in the lowlands, resources are set to decrease by between 4.4 and 7.8%.
4. Scenario B2 is more «pessimistic» on the whole, as in the next 50 years runoff in mountainous areas are poised to drop by 7.2–19.3%, while a 3.2 increase is set to occur in the western Altay. Water resources in lowland river basins will increase by 8–8.5 %.

5. An assessment of sensitivity of water resources over various years suggests that, irrespectively of the water content over the year, changes in water resources tend to follow the same trend as the one they follow over the entire periods of time.
6. All scenarios envisage an increase in both precipitation and temperature. In mountain areas, due to an increase in winter precipitation in particular in zones from where the runoff to river basins originates, snow reserves provide additional runoff in spring. The increase in air temperature will not be strong enough to cause early slides among soil layers which thereby boosts the loss of runoff during spring floods. In lowland basins, though, the situation is different. An increase in precipitation does not significantly influence the runoff volume as a consequence of major losses in watershed zones. Lowland basins are more sensitive to rises in air temperature which reduces the depth of permafrost, thereby increasing losses in runoff due to infiltration.

As for **Kyrgyzstan**, surface runoff in the assessment and modelling of the process of climate change is calculated as the difference between annual precipitation and annual evaporation. The results of this calculation show that substantial decrease in surface runoff can be expected under any of the most probable scenarios. At the same time, surface runoff is expected to increase during a period that lasts until some point between 2020 and 2025 due to an increase in glacier melting. After that, it is set to decrease to 20.4–42.4 km³, or in the range 43.6–88.4% of the level in 2000. Evaporation is mainly responsible for the decrease in runoff following an immediate increase in the beginning of the XXI century.

In **Uzbekistan**, forecasted climate change is to be determined by greenhouse gas emissions scenarios, the condition of the global climate system and the various models allowing assessments of perspectives in runoffs. The effect of the climate on runoff varies depending on any specific scenario, and is by and large being determined by differences in precipitation under various scenarios. Bearing in mind the high natural variability of precipitation observed by the region's meteorological stations, the absence of any clear pattern in them and a high degree of uncertainty accompanying each scenario, there have been two options:

- 1) to calculate changes in precipitation and temperature for each scenario;
- 2) to calculate changes in temperature per scenario under current precipitation patterns.

In order to assess the effects of climate change on river runoff, a mathematical model was used in respect to the runoff of mountain rivers. This model has been applied in the form of an automated information system for hydrological forecasts and calculations.

The assessment of the Aral Sea basin runoff within Uzbekistan's territory based on various climate change scenarios indicates that:

- 1) in the event of a climate scenario envisaging changes in both precipitation and temperature, no significant changes in the Syr Darya basin will occur through to the year 2030. In the event of scenario B2, an insignificant increase in runoff in the upstream course can be expected, but on the whole any deviations will not exceed those within the natural fluctuations of runoff. In the Amu Darya basin, a mild downward trend can be observed;
- 2) in the event of an increase in air temperature and stable precipitation, by 2030 water resources in the Amu Darya basin could decrease by 5 to 8% as compared to their current level, while any deviations in the Syr Darya basin are expected to be within the natural runoff fluctuations;
- 3) a long-term change of temperature stretching over a period that lasts until 2050 alone may reduce the runoff of both the Syr Darya and the Amu Darya, in which the former's runoff is to decrease by 6–10% and the latter's by 10–5%;
- 4) a similar situation is set to develop by 2050 in the Amu Darya basin under scenario A2, while in that case the Syr Darya basin's water resources could drop by 2 to 5% as compared to their current level.

While using both temperature and precipitation as parameters, in Tajikistan we can identify the following trend in its major rivers' runoffs depending on the share of glaciers in water supplies to them.

Calculations show that as compared with runoff levels during the second half of the XX century, as of 2020 river runoff in the Amu Darya basin will decrease by 3%, as of 2035 by 5% and as of 2050 by 6%.

An increase in runoff following a 14% increase in annual precipitation under scenario HadCM2 is expected to remain insignificant. A 6% decrease of the total runoff of the Amu Darya by 2050 can also be viewed as minor.

The temperature and precipitation scenarios allow forecasting runoff trends for the major rivers depending on the share of glaciers in their water supplies, as shown in Table 6.1.

River station	Average annual runoff (km ³)			
	1990 (standard)	2020	2035	2050
the Kafirnigan, Tartki	5.11	5.01	4.98	4.94
the Vakhsh, Darband	19.1	18.3	17.9	17.6
the Pyandzh, New Pyandzh	31.9	30.7	30.2	29.7
Total	56.1	54.0	53.1	52.2
Decrease in 1990–2050	–	2.1	3.0	3.9
% of standard	–	3	5	6

Table 6.1. Decrease in glacier and total runoff (%) after warming by +20C and depending on the share of glaciers in river feeding (%)

The forecasted warming process is due to cause shifts in the data that apply to the start, peak and ending of spring floods. Calculations show that the most significant changes are due for the beginning and further development of spring floods. Their time span is supposed to increase as a result of warming in the run-up to their beginning and as they draw to a close:

- by 30 to 50 days in rivers fed mainly by glacier and to lesser extents by snow melt water;
- by 15 to 20 days in rivers fed mainly by snow and to lesser extents by glacier melt water;
- by 8 to 10 days in rivers fed by snow melt water and rain.

The peak of spring floods may be reached at anticipated stages:

- by 15 to 25 days in rivers fed mainly by glacier and to lesser extents by snow melt water;
- by 7 to 10 days in rivers fed mainly by snow and to lesser extents by glacier melt water;
- by 25 to 30 days in rivers fed by snow melt water and rain.

In this way, due to the forthcoming anthropogenic climate change the water resources of the northern plains of Central Asia are set to decrease by 6 to 10% by 2030 and by 4 to 8% as of 2050.

These decreases will be due as warming in lowland river basins reduces the depth of permafrost, thereby increasing losses in runoff due to infiltration and, of similar importance, reduces the period of snow accumulation in the run-up of spring floods.

6. Assessment of changes in water resources of the main cross-border rivers in Central Asia

In mountainous areas, runoff is set to change within the natural fluctuation range until 2030, from where it may decrease by 7–17% through to 2050.

During the first half of the XXI century, runoff is poised to be strongly affected by the melting of glaciers which goes back to the early XVIII century, which marked the end of the so-called Minor Ice Age during which they developed as the air temperature lowered and precipitation levels increased. The melting process started in the second half of the XX century and persists into the first half of the XXI century. This process has led to an increase of river runoff by 4–6% in the southern mountain areas and by 10–15% further to the north, in the Naryn and Balkash basins.

At a later stage, as water reserves in glaciers deplete and the draining of water resources in the river basins downstream the deglaciated areas intensifies, the inflow of melt water through rivers is bound to dwindle.

As a result of total deglaciation, which experts expect to occur during the last decades of the XXI century, the water resources of mountainous regions will shrink by 10–12%. Deglaciation is also set to increase the volatility of runoff fluctuations both year-on-year and over subsequent periods of several years. In particular, runoffs in the period from July to September are due to diminish while runoffs in spring and autumn are poised to rise.

The current and upcoming climate change is to be accompanied by an increase in volatility, frequency and intensity of hydrological droughts.

7. Modern regional climate change models

In order to review climate changes in Central Asia, data from the Tyndall Centre for Climate Change Reserve at the University of East Angling have been used. Calculations in respect to temperature and precipitation during the last decades of the XXI century, from 2071 to 2100, have been based on two greenhouse gas concentration scenarios, A2 and B2, and four global climate models: Australia's CSIRO2, Canada's CGCM2, the United Kingdom's HAD3 and the United States' PCM. These models have been approved by the Intergovernmental Panel on Climate Change (IPCC).

All these models and scenarios envisage that by the end of the XXI century, average annual and seasonal temperatures will have risen throughout Central Asia (see Figures 6.1–6.5). Precipitation is expected to decrease during summer and increase during winter, while trends in spring and autumn tend to vary.

Under scenario A2, by the end of the XXI century the increase in average annual air temperature as compared with the base period (1960–1990) will vary from 4.7°C in Turkmenistan to 5.6°C in Kyrgyzstan in all models. Different models give varying numbers in terms of temperature changes: from 3.3–6.7°C in Kazakhstan, from 3.3–7.1°C in Kyrgyzstan, from 3.4–7°C in Tajikistan, from 2.8–5.9°C in Turkmenistan and from 3–6.7°C in Uzbekistan. Annual precipitation will increase in all countries except for Turkmenistan: by 46% in Kyrgyzstan, by 27% in Kazakhstan, by 18% in Tajikistan and by 7% in Uzbekistan.

Under scenario B2, which should be seen as more «optimistic», the expected rise in annual air temperatures will be 1–1.5°C lower than under scenario A2, while changes in precipitation will be the same.

Season-wise changes in air temperature and precipitation can be described as follows:

Winter. Under scenario A2, change in winter air temperatures by the end of the XXI century in all models is poised to vary from +4.1°C in Turkmenistan to +5.6°C in Kyrgyzstan. The expected average seasonal temperature increase will be limited to 3.3–6.7% in Kazakhstan, 3.7–7.7°C in Kyrgyzstan, 3.6–7.6°C in Tajikistan, 2.3–5.8°C in Turkmenistan and 2.7–7.2°C in Uzbekistan. Winter precipitation will increase throughout Central Asia, varying from a 29% high in Tajikistan to a 6% low in Turkmenistan. The increase in precipitation will vary 6–20% in Kazakhstan, 15–46% in Kyrgyzstan, 16–53% in Tajikistan, 3–10% in Turkmenistan and 3–14% in Uzbekistan.

Under scenario B2, winter air temperature will increase by 4°C in Kazakhstan, Kyrgyzstan and Tajikistan, by 3°C in Turkmenistan and by 3.7°C in Uzbekistan. Precipitation in these countries is set to increase by 14, 21, 28, 5 and 12% respectively.

Summer. Under scenario A2, average air temperature can be expected to increase throughout Central Asia by 5.1–5.5°C on average. Precipitation will dwindle by 4–21%, with extremes occurring in Tajikistan.

Under scenario B2, summer air temperature is poised to increase by 3.8–4°C, while precipitation can either be seen decreasing by 10% or unchanged.

Spring. Under scenario A2, spring air temperatures will increase by 6.2°C in Kazakhstan, by 6.3°C in Kyrgyzstan, by 5.6°C in Tajikistan, by 5.2°C in Turkmenistan and by 5.8°C in Uzbekistan. All models indicate that precipitation is bound to increase both in Kazakhstan and in Kyrgyzstan by 19–33% respectively. In Turkmenistan it can be expected to decrease by 11%, whereas Tajikistan and Uzbekistan fail to show a clear pattern.

7. Modern regional climate change models

Under scenario B2, spring air temperature is due to increase by 4.2°C in Kazakhstan, by 4.1°C in Kyrgyzstan, by 3.8°C in Tajikistan, by 3.6°C in Turkmenistan and by 3.9°C in Uzbekistan. Precipitation changes are expected to occur to the same ratios as under scenario A2.

Autumn. Under scenario A2, average air temperatures are set to increase by 4.4°C (+2.9 +5.3°C) in Kazakhstan, by 5.0°C (+2.8 +6.3°C) in Kyrgyzstan, by 4.7°C (+3.0 +6.1°C) in Tajikistan, by 4.4°C (+2.8 +5.1°C) in Turkmenistan, and by 4.5°C (+2.9 +5.4°C) in Uzbekistan. Precipitation trends vary according to different models, from minus 2 to plus 6% in Kazakhstan, from minus 9 to plus 4% in Kyrgyzstan, from minus 7 to plus 7% in Tajikistan, from minus 3 to plus 3% in Turkmenistan and from minus 2 to plus 5% in Uzbekistan.

Under scenario B2, autumn air temperature is bound to increase by 3.4°C (+2.8 +3.9°C) in Kazakhstan, by 3.7°C (+2.6 +4.5°C) in Kyrgyzstan, by 3.6°C (+2.7 +4.6°C) in Tajikistan, by 3.4°C (+2.7 +4.1°C) in Turkmenistan and by 3.5°C (+2.8 +4.2°C) in Uzbekistan. Precipitation changes are expected to occur to the same ratios as under scenario A2.

8. Recommendations concerning the efficient use of water resources in the region including hydropower potential

Bearing in mind the sensitivity of water resources to the potential anthropogenic climate change, adaptation to the new conditions becomes a task that should be on top of the list of priorities. Measures necessary to adapt will mainly be determined by specific need for water among its users. In all southern countries, agriculture is the most demanding user of water as it consumes up to 90% of the resources supplied through rivers. While determining adaptation measures, it should be taken into account that the expected decrease in surface water runoff is doomed to be aggravated by extreme climatic conditions, a phenomenon for which no reliable long-term forecast can be made at the present stage. Nevertheless, it can be considered fairly certain that floods are to become more destructive and lengthy, while droughts are set to occur more frequently and last over longer periods of time as well.

Inclusion of compulsory provisions on climate change in various regional and national plans and programmes is an adaptation measure in itself. In the cases of Kyrgyzstan and Tajikistan, such provisions are required to be included in the plans for all hydropower development projects.

An optimal approach would be to implement several regional pilot projects aimed at adaptation to climate change and share their results across the region.

Furthermore, adaptation to expected changes in supplies from water resources should include the following priorities:

at a regional level:

- the most drastic possible measures to be taken in terms of projects of re-routing portions of runoff within the region or from neighbouring regions;
- priorities to be given to water saving and environmentally protective measures;
- an emulation system to be developed with the purpose of detailed assessment and management of water resources;

at national levels:

- water saving technologies to be implemented in agriculture, industry and utility sectors;
- responses to the threats represented by deglaciation in the form of reservoirs to be designed and constructed on mountain rivers, basically for the purpose of seasonal runoff regulation, along with protective hydraulic engineering structures.

Given these priorities along with the multi-ethnic populations in the basins of the Syr Darya and the Amu Darya, the following range of measures should be taken in the future for the management of crucial water resources in Central Asia. These measures serve the interests of the entire region and are meant to build and develop a mechanism of cooperation between countries based on a common approach.

Measures to support water-consuming economic sectors:

- strategic economic development with an emphasis on «dry» or water-economical technology;
- introduction of water-saving technology in irrigated farming;
- increase in the use of water from subterranean deposits;
- a system which regulates surface water runoff and accumulation of water in reservoirs;

8. Recommendations concerning the efficient use of water resources in the region including hydropower potential

- campaigns to incite users to economise on water consumption through the introduction of fees;
- a shift towards drought-resistant varieties of crops which are more fit to adapt to climate change;
- the rerouting of a portion of river runoffs within the region or from outside the region.

Measures to mitigate the negative consequences of the deterioration of water resources:

- minimising water losses by improving management of water supply systems and refurbishing their infrastructures;
- replacing hygrophilous crops in irrigable areas by drought-resistant ones;
- introducing advanced technology in irrigated farming;
- using modern, more efficient water distribution systems and conditions with the aim to reduce losses of water;
- introducing new technologies and building water supply systems aimed at reducing losses of water in the industry and utilities sectors;
- recycling wastewater;
- reducing the share of HPP in overall power supplies and consumption in areas generating river runoffs, by switching to nuclear, solar and wind energy resources, in order to save water in winter to be saved for irrigation in summer;
- dredging river beds and providing navigable rivers with berths;
- replacing existing river transport and fishing vessels with boats that have less draught.

Measures to optimise the condition of aquatic ecosystems and ecological protection:

- creating favourable water and thermal conditions to sustain and cultivate fish and other animals through population control;
- building installations for chemical and biological treatment of wastewater;
- taking measures to reclaim vegetation and forest land and using agro-technical tools to ensure environmental safety;
- establishing protective zones near surface water sources and groundwater intake points;
- limiting economic activity in the most arid areas and transferring them to other districts;
- determining defined zones for core production sectors of agriculture;
- imposing compulsory EIA of new projects connected with the use of water resources.

Measures to streamline decision making:

- synchronising legislation and concluding international agreements that regulate relations in regard to the use of water in connection with projected changes to water resources;
- strengthening the competence and legal framework of international organisations;
- improving the timeliness and accuracy of hydrological forecasts;
- developing models and scientific recommendations in order to assess varieties of situations related to the generation and use of water resources;
- ensuring that respective authorities are ready to implement urgent decisions;

8. Recommendations concerning the efficient use of water resources in the region including hydropower potential

- assessing surface water resources and their characteristics in statistics under changed conditions with the purpose to develop programmes for the efficient use of water resources and to design hydraulic engineering structures;
- elaborating runoff registration and monitoring systems within the framework of cross-border water resources, and strengthening hydrological monitoring in order to determine forecasts of water resources and their changes due to climate change;
- improving awareness and skills related to sustainable water resources management;
- developing an overall system of hydrological forecasting;
- developing a timely prevention system of hydrological droughts
- developing mechanisms of comprehensive water resources management in the Aral Sea basin.

These measures could facilitate a regional approach to water distribution challenges in the Aral Sea basin. Problems in particular involve the unequal positions of upstream and downstream countries.

In addition to the regional measures proposed in the previous paragraphs, national measures are on the agenda for Kazakhstan, Kyrgyzstan, Tajikistan and some parts of Uzbekistan which are under threat of increased mudflow activity due to changes in the climate.

Under changing climate conditions, as mudflow activity can increase in terms of frequency and intensity by dozens of times, protective measures are required of both political and economic character.

Protection against mudflow includes measures regarding territorial management and economic development. Examples are the prevention of reservoir bursts which can cause mudflow, draining hazardous reservoirs within glacier structures, amelioration of zones from where mudflow caused by rainfall originate, rehabilitation of vegetation on the mid-level slopes of mountains and foothills, terracing of foothill slopes, constructing basins in which debris from mudflow that result from outbursts from underground water deposits or from heavy precipitation occurring at heights above the common sources of mudflows, as well as influencing the intensity, lengths and phasing of precipitation.

Measures in territorial management and of economic character are aimed at minimising the threat of mudflow and mitigating potential damage.

These measures impose limits on economic activity in areas prone to mudflow, by preserving the vegetating that covers watershed areas, recultivation of natural landscapes, locating leisure resorts in safe places, introducing a warning system for mudflow threats, an improving safety awareness in areas prone to mudflows.

Protective measures, starting with hydraulic engineering, ensure the safety of utility sites threatened by mudflow through mudflow retention, redirecting the slides away from protected areas, make them circumvent exposed facilities, etc. To date, there are no commonly accepted or approved methods of protection against mudflow. It should be taken into account that no preventive measures can grant total protection, which is the reason why e.g. debris collection basins should be established in mountain valleys. If the location of such basins counts few inhabitants and the costs of preventive measures largely exceeds the value of the infrastructure under protection, and in case lands are being claimed for protection purposes, it will be more economical to redirect mudflow through protected areas or to allow them to accumulate debris in the basin.

Each of the mudflow that originate from high mountain levels and create havoc in river valleys and debris basins has its own specific characteristics, and it is therefore that each basin under the threat of mudflow requires its own specific protective strategy.

8. Recommendations concerning the efficient use of water resources in the region including hydropower potential

A preliminary assessment of the hydropower potential of Kyrgyzstan and Tajikistan indicates that protective and adaptive measures need to be implemented in the region. Water, just to mention one factor, is an energy resource for these two countries which receive 90 to 94% of all their energy from HPP. When in the last century the hydropower potential of the two countries was assessed, it was done without taking climate change into account, and therefore now the assessment needs to be revised. An assessment, based on the lake Issyk Kul, as an example, indicates that the impact of climate change is very tangible indeed. Under the most favourable climate scenario, the total hydropower potential of the rivers flowing into Issyk Kul may drop to hardly more than half of its previous level by 2100. On the whole, comprehensive studies should be carried out in the region in order to compose an unbiased assessment of the condition of its water resources, including the hydropower potential of cross-border rivers.

9. Recommendations regarding food security in the context of the impact of climate change on agriculture

Among the various economic sectors, close attention is being given to issues relating to agriculture and food security in studies on the effect of climate sectors. Many countries have started to look at possibilities to grow varieties of crops such as wheat, maize, rice and other cereals, cotton, vegetables, vines, fodder grass, under different climatic conditions and assess their potential advantages and disadvantages. On one hand, crop cultivation may benefit from longer growing seasons and higher atmospheric concentrations of CO₂. On the other hand, higher temperatures may reduce soil humidity; facilitate the spread of weeds, pests and infectious crop diseases, apart from reducing biodiversity. On the whole, negative consequences will prevail, resulting in an overall decrease in productivity in the range of 15 to 50%.

Similar scenarios have also been conceived for livestock productivity. Some countries pin their hopes on higher CO₂ concentrations since they will give longer pasturing seasons. However, scenarios indicate that livestock productivity will drop as a result of dwindling areas of pasture land and a 30% decrease in the fertility of existing pastures.

In addition to the effect of climate change, there are risks involved in the variability of changes in climatic conditions, which most of all regard agriculture. Although most scenarios include an increase of the productivity of steppe land due to higher CO₂ concentrations in the atmosphere, productivity is also bound to be affected by negative phenomena such as excessive precipitation, floods and droughts.

Farms and rural populations are facing more and more difficulties due to climate change and the need to adapt to its negative consequences. Therefore, a clear adaptation strategy should be developed for agricultural and rural areas. This is bound to include certain issues such as the question whether which options in terms of adaptation are economically and technically feasible, which alternative crops can be cultivated in various areas in an economically viable manner as climate change advances, how timing for this can be conceived in the best possible way. Questions also regard factors that impede adaptation, whether or not it is possible to secure synergetic benefits, and how issues concerning adaptation can be integrated into overall management strategies and policies in respect to agricultural and rural development.

A higher level of understanding of regional impacts of climate change and its effect on agriculture will pave the way to define regional strategies in order to respond to negative consequences or to use positive ones by adapting existing conditions. Close attention should be paid to reducing the emissions of greenhouse gases in agriculture and to increasing carbon sequestration, e.g. by defining proper agricultural and management methods and through well-programmed interventions. Any reliable and successful climate change response policy should be comprehensive. Therefore, agriculture should be integrated into the overall program strategy of GHG emission prevention. Agriculture has a good potential for reducing GHG emissions at low cost.

Central Asian countries are increasingly exposed to droughts. Shortages of precipitation therefore directly affect those sectors of the economy that subsist on water consumption such as industry, energy and transport. In addition, inadequate distribution of water among different sectors of the economy tends to tilt the balance between water supply needs and available water resources. Shortage of water intake and droughts strongly affect natural resources' availability as a whole, resulting in the loss of biodiversity, deterioration of water quality, increased risk of wildfires and loss of soil fertility.

The urgency of the problems caused by droughts in Central Asian countries depends on its effect on the population, the economy and the environment, along with the available potential

for response and rehabilitation. Therefore, in order to address this problem at subregional and local levels, a comprehensive approach should be opted for, including a system of monitoring droughts and preparing preventive and responsive measures. In recent decades, droughts in Central Asia have increased poverty, undermined food security, and caused migration waves. It is also expected that water resources in the region will become increasingly stressed alongside by deglaciation and climate change. Areas prone to drought will expand, and it is therefore that a shift from crisis management towards drought risk management should become a regional-level priority. Accordingly, a wide range of programme options needs to be taken under consideration. Since water is vital for human physical, economic and social life, switching to efficient water-saving economic activity is an integrated part of overall challenges for the future.

Despite the increasing exposure of Central Asia's community to droughts, the ability to assess the problem through monitoring and forecasting is not yet up to a level that would allow to design proper expectation patterns and base adequate response strategies on them. Therefore, establishing regional centres for drought control in Central Asia with the participation of end users is a difficult task even though it is imperative as a condition to get prepared for setbacks on both regional and local levels. Central Asian countries should also finance and/or raise funds for the transfer, acquisition, adaptation and development of environmentally friendly, economically viable and socially acceptable response devices to drought.

Efforts to create such efficient and sustainable devices require long-term investments. But although the costs of creating and maintaining land and water resources management systems are relatively high, the benefits of such systems, provided they function in an adequate manner, provide a basis for sound economic development and national social progress.

The achievement of the goals described above will largely depend on the respective countries' institutional readiness. Considerable efforts and investments should be made to create and maintain institutional support for an efficient land and water management system, with environmental considerations being an integral part of them. There is a need for the build-up of a legal framework that allows control over decision making and implementing concerning land and water management. Central Asian countries should consider raising additional funds from national and international sources, in order to be able to adopt adequate practices of the use and monitoring of land and water resources in developed countries.

10. International recommendations for measures to strengthen regional cooperation in the basins of cross-border rivers in the context of the impact of climate change on water resources

The international community is paying close attention to issues relating to climate change and its effect on sustainable development. Risks associated with climate change cause growing concern, and therefore UN regional committees have developed approaches in respect to the assessment of economic and social consequences of climate change, in addition to analyses of its environmental aspects and its consequences for regional development.

The efforts by the international community are aimed at slowing down changes in climate or at mitigating their negative consequences. The Intergovernmental Panel on Climate Change has published a report under the title *Climate Change 2007*. This paper provides a review of research, technical and socioeconomic data needed to comprehend the climate change process and its potential effect, as well as methods of adaptation and of mitigating its negative consequences. The report includes a comprehensive summary of all currently available data on climate change.

The results of the observations conducted on all continents and in most of the oceanic zones suggest that climate change, and global warming in particular, affects virtually all environmental systems. The overall trend indicates that the faster the temperature rises, the higher the risks of negative consequences becomes. Warming has already speeded up the hydrological cycle. A warmer atmosphere retains more moisture and becomes less stable. As a result, precipitation increases, especially in the form of heavy rainfall. Warming also intensifies evaporation. This eventually results in changes to water circulation, triggering depletion and deterioration of fresh water reserves in all regions at large, as well as changes in the patterns of winds and the direction of cyclones.

Due to extreme weather conditions, the incidence rate of natural disasters between 2000 and 2006 around the globe increased by 187% as compared to the previous decade. It is expected that these adverse changes will affect many countries, causing either extreme increases or extreme decreases in air temperature, affecting people's health. Climate change also causes floods and droughts, accelerates depletion and contamination of water sources, thereby worsening sanitary conditions. Ecosystems are already being affected by transformations associated with water circulation conditions: sources of surface water are drying up, temperatures change, algae are spreading and certain species are extinguishing. All these factors reduce the stability of ecosystems, including those in river basins.

Some of the phenomena mentioned above, such as floods, erosion and deglaciation, are already being observed in northern Europe. In central and eastern Europe, summer precipitation is expected to drop. High temperature and drought are being registered in Central Asia, the Caucasus and southern Europe, and right now they already affect the availability of water resources, hydropower capacity and crop productivity.

The ability to adapt to climate change is crucial for economies which depend on water resources, and it is therefore that taking measures to do so should become both a national and a regional

10. International recommendations for measures to strengthen regional cooperation in the basins of cross-border rivers in the context of the impact of climate change on water resources

priority. The negative effect of climate change hits developing countries hard since their economic resources remain insufficient to implement adaptation measures. These countries need international assistance. Where water resources are used jointly by various countries, all interested parties should develop coordinated initiatives and mobilise their financial resources. The report mentioned above indicates that political and economic incentives may help to develop new production technology with low GHG discharges. Therefore, the IPCC proposes political and economic initiatives aimed at reducing the emissions of GHG into the atmosphere, thereby adapting to climate change. The report concludes that:

- governments can play a key role in encouraging private sectors to invest in advance technology by providing transparent, predictable and stable incentives;
- political initiatives should be multi-layered, with governments deploying a wide variety of political instruments such as standard requirements, taxes, duties, trade permits, voluntary agreements, subsidies, financial compensations, research and development programmes and information. An optimised approach regarding political initiatives may vary depending on a country's economic situation;
- public investments in energy infrastructure are an important factor in exercising a long-term influence on GHG discharge levels;
- governments should identify and eliminate barriers to efficient policy innovation and its implementation. Such barriers include market prices which stand in no relation to contamination and other factors, inappropriate incentives, property rights, lack of inefficient management and incomplete information;
- no single technology can provide an overall decrease in negative consequences of climate change. The best approach is to deploy all possible political initiatives addressing the core areas of concern.

In cooperation with the executive committee of the Protocol for Water and Health Problems, water resource experts of the UNECE prepared a draft manual on adaptation of water resource management to climate change in the east- and central Europe region and beyond. This manual describes how countries can implement the Convention on the Protection and Use of Transboundary Water Resources and International Lakes in relation to climate change. This document provides a step-by-step approach towards the assessment of the effect of climate change, policy formulation, and strategic and practical adaptation measures. It is essentially a plan of action which needs to be adapted to conditions on local levels.

The manual describes:

- the basic principles, general policy and institutional and legal framework of efficient planning and implementation of adaptation measures;
- information gaps and requirements relating to the assessment of the effect of climate change on the availability of water resources and services according to the various climate models and scenarios, as well as hydrological models of water levels in basins;
- the assessment of sensitivity on local and national levels in order to designate areas, population segments and ecosystems most exposed to risks, and means and methods to be used in order to eliminate or reduce those risks.

The adaptation phases include:

- prevention, including an action plan and a concept legal framework, and elimination of the worst consequences of natural disasters such as drought and floods;
- improvement of the viability and sustainability of water circulation systems by upgrading irrigation, desalination, water level control, safety of dams, land use planning etc.;
- preparation for extreme weather conditions by enhancing awareness, fair distribution of water resources and joint management;

10. International recommendations for measures to strengthen regional cooperation in the basins of cross-border rivers in the context of the impact of climate change on water resources

- response to extreme weather conditions, including evacuation, medical emergency assistance, distribution of safe drinking water, management of hazardous substances, institutional development, personnel training and divulging information;
- preparation for rehabilitation, reconstruction, legal measures, collecting and circulation of information in case of emergencies.

The ministerial declaration adopted by the V World Water Forum in March 2009 stresses the need to comprehend the effect of global climate changes on water resources, natural hydrological processes and ecosystems. The declaration contains a call for changing the attitude towards forecasts, climatic and hydrological information support for agriculture, and joint access to and use of the climate change and hydrological process database.

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Journal of Eurasian Economic Integration

The Journal of Eurasian Integration is a quarterly academic and analytical journal published in Russian by the Eurasian Development Bank. The members of Editorial Board and Advisory Council are distinguished academicians, practitioners and experts in regional integration. Eurasian Economic Integration brings together academic and analytical articles, reviews of books relating to regional integration, interviews and quarterly chronicles of regional integration. With its focus on economics, the journal is a rich source of material addressing a broad range of issues specific to Eurasian integration. These include integration theory and its relevance to the development context; economic integration (trade, investment, financial institutions); institutional integration; cooperation issues in the post-Soviet space; and international experience of regional integration. The first issue was published in the third quarter of 2008.

Requirements for submissions. Papers should be sent by e-mail to editor@eabr.org for blind review. There are no strict limitations on the length of articles. However, the Editorial Board recommends authors to adhere to 6000–8000 words or 30000–40000 characters. In addition to the main text, authors must a brief author(s)' biography (100–150 words), executive summary (100–150 words) and bibliography. These materials must be attached in a separate file.

EDB Eurasian Integration Yearbook

Eurasian Integration Yearbook publishes wide range of articles and other materials in English language on theory and practical aspects of Eurasian integration. The major part of the annual Yearbook consists of English versions of selected articles published in the Journal of Eurasian Economic Integration and other analytical publications of EDB. These will be supplemented by integration chronicles for the respective year. The Yearbook will improve access of the world community to the best papers on various issues of regional integration published in Russian language. Apart from papers published in the Journal of Eurasian Economic Integration, papers written specifically for the Yearbook are also welcome (submission in English or Russian).

Sector reports

As of today the following Sector reports have been published and distributed:

- Nuclear Energy Complexes in Russia and Kazakhstan: Prospects for Development and Cooperation. April 2008.
- Water and Energy Resources in Central Asia: Utilization and Development Issues. April 2008.
- The CIS Common Electric Power Market. August 2008.
- The Eurasian Development Bank's Investment Policy and the Environment. February 2009.
<http://www.eabr.org/rus/publications/AnalyticalReports/>

Consultancy

The Bank provides consultancy services to its strategic partners and clients. The Bank's Strategy and Research Department has in-house expert resources and can involve specialists from other departments, such as project managers, corporate financing, treasury, legal department. External experts from the extensive pool of CIS countries' experts could be mobilised to work on consultancy projects.

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- Development banks' operations and activities in the CIS countries and issues of cooperation.

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