

Assessment

Table 7 Scoring table for the Aral Sea region.

Assessment of GIWA concerns and issues according to scoring criteria (see Methodology chapter).		The arrow indicates the likely direction of future changes.					
IMPACT INDEX	0 No known impact	IMPACT INDEX	2 Moderate impact	IMPACT INDEX	3 Severe impact		
	1 Slight impact					↗ Increased impact	
						→ No changes	
						↘ Decreased impact	
Aral Sea		Environmental impacts	Economic impacts	Health impacts	Other community impacts	Overall Score**	Priority***
Freshwater shortage		3.0* ↗	3.0 →	2.8 →	2.3 ↗	2.9	1
Modification of stream flow		3					
Pollution of existing supplies		3					
Changes in the water table		3					
Pollution		2.4* →	2.4 →	2.8 →	2.3 →	2.5	2
Microbiological pollution		0					
Eutrophication		1					
Chemical		3					
Suspended solids		1					
Solid waste		2					
Thermal		1					
Radionuclide		1					
Spills		1					
Habitat and community modification		2.4* →	2.4 →	2.4 →	2.3 →	2.4	3
Loss of ecosystems		2					
Modification of ecosystems		3					
Unsustainable exploitation of fish		0* →	0 →	0 →	0 →	0	5
Overexploitation of fish		0					
Excessive by-catch and discards		0					
Destructive fishing practices		0					
Decreased viability of stock		0					
Impact on biological and genetic diversity		0					
Global change		1.0* →	1.0 →	1.0 →	1.0 →	1.0	4
Changes in hydrological cycle		0					
Sea level change		1					
Increased UV-B radiation		1					
Changes in ocean CO ₂ source/sink function		0					

* This value represents an average weighted score of the environmental issues associated to the concern. For further details see Detailed scoring tables (Annex II).

** This value represents the overall score including environmental, socio-economic and likely future impacts. For further details see Detailed scoring tables (Annex II).

*** Priority refers to the ranking of GIWA concerns.

This section presents the results of the assessment of the impacts of each of the five predefined GIWA concerns i.e. Freshwater shortage, Pollution, Habitat and community modification, Unsustainable exploitation of fish and other living resources, Global change, and their constituent issues and the priorities identified during this process. The evaluation of severity of each issue adheres to a set of predefined criteria as provided in the chapter describing the GIWA methodology. In this section, the scoring of GIWA concerns and issues is presented in Table 7.

IMPACT Freshwater shortage

The rational use of water resources is a major component of the present-day strategy of nature management and sustainable development. Problems associated with the sharing of transboundary water resources can provoke conflicts and are becoming the subject of increasingly complicated interstate negotiations. The rapid development of irrigated areas in the region has destabilised the water level of the Aral Sea and is jeopardising the preservation of ecosystems in Priaralye.

This situation is accompanied by poor water quality as a result of the discharge of drainage water from irrigated areas. Consequently in the early 1990s the socio-economic and ecological situation in Priaralye was assessed as critical.

The freshwater concern is inextricably linked with the other assessed concerns. In particular, habitat modification of the Aral Sea and the Syrdarya and Amurdarya river basins, and the resultant changes in abundance and distribution of biological resources was caused by the upstream modification of streams for the purposes of irrigated agricultural. Therefore to obtain a comprehensive understanding of

the freshwater shortage concern, refer to the habitat modification concern.

Environmental impacts

Modification of stream flow

The most acute problem in the Aral Sea region is the irrational use of surface water resources. The volume of water consumed in the areas of the region where water is predominantly used is largely determined by the interests of irrigated farming, which accounts for 50% of GDP (Schultz 2002). A sophisticated farm-to-farm and inter-farm irrigation network of a total length of 316 000 km and a drainage system of a total length of more than 190 000 km have been constructed in the region (Duskayev 2000). A complex system of river flow regulation includes a large number of river and off-river water reservoirs, and is controlled by two basin administrations; the Syrdarya and the Amudarya offices which were established before the collapse of the USSR. These offices were incorporated into the Interstate Coordination Water Management Committee (ICWC) in 1992.

On the territory of Uzbekistan, in addition to numerous ponds and small-capacity water reservoirs used for irrigation, 50 relatively large reservoirs with a total volume of 19 km³ have been constructed. The total volume of reservoirs constructed on the Syrdarya in Uzbekistan is 5 km³, and 29 water-storage reservoirs with a total capacity of 14 km³ have been built on the Amudarya. The largest water reservoirs are Charvak water reservoir on the Charvak River near Tashkent and Andizhan water reservoir in Osh valley on the Karadarya River. The existing reservoirs have a run-off control rate of 0.94 for the Syrdarya (i.e. close to its maximum), and 0.78 for the Amudarya, with capacity for further increases. Upstream flow regulation in the Amudarya Basin is provided by three main reservoirs, namely the Nurek and Baypasin on the Vakhsh River and the Tuyamuyun on the Amudarya, as well as by a network of river reservoirs and their associated canals. There are four river reservoirs on the Karakum Canal, two on the Amubuchara Canal and one on the Karshin Canal, which can hold a combined volume of 6 km³ (SPECA 2004).

The greatest consumer of water resources is Uzbekistan which, on average, uses approximately 54% of the region's total water resources, a figure which rose to 60% in 1999. Turkmenistan uses about 19% of the regional water resources. The overwhelming proportion of river flow (almost 68%) is formed on the territory of Tajikistan and Kyrgyzstan, yet the main irrigated areas where most of the total river flow is used are located on the territories of Uzbekistan, Turkmenistan and, to a lesser extent, in Kazakhstan. It is estimated that more than 90% of total water resources are used by irrigated farming in these countries, and this

percentage remains relatively consistent from one country to another, fluctuating between 88.5% and 92.6% (Kipshakbayev & Sokolov 2002).

Irrigated areas in the Aral Sea Basin grew from 4.51 million ha in 1960 to 6.92 million ha in 1980 and to 7.85 million ha in 2000. Accordingly, total water intake for irrigation rapidly increased and by the beginning of the 1980s had reached 120.7 km³/year and overall water consumption in the Aral Sea Basin exceeded the available river water resources. Today, due to the use of return waters, the volume of water resources used exceeds available supplies; in the Syrdarya Basin 130-150% of available water resources are used and in the Amudarya Basin, 100-110% (Kipshakbayev & Sokolov 2002).

Naturally, the increase in water consumption, particularly in low-water years, has severely affected the numerous rivers in the region. The Irtysh and Ishym in the east, the Chu, Talas, Syrdarya and Amudarya in the south, the Ural in the west and the Ishim and Tobol in the north are transboundary rivers and the largest of these, the Amudarya and the Syrdarya, cross the borders of three or more countries. In the Amudarya Basin the reduction in river flow following the construction of the Takhiatash and Tyuyamuyun reservoirs and the excessive use of water in irrigated areas has modified the delta and floodplain environment. By the year 2000 the total annual run-off of the Amudarya near the estuary (Chatly-Samanbay measuring station) had reduced by almost ten times in comparison with 1970. As a result, less than 10% of the total area of delta lakes in the Amudarya lower reaches remained, and the once profitable fishery and water rat fishery practically disappeared. Furthermore, some regions in Tajikistan suffer from water deficiency, despite being on the territory where the majority of the Amudarya flow is formed and which seems to have an excess of water resources (Olimov 2001).

The reduction in the flows of the Amudarya and Syrdarya rivers resulted in a decline in the water level of the Aral Sea and threatened the preservation of the Priaralye ecosystem (Kamalov 2002). The area of the Aral Sea has reduced more than two-fold. In 1986, the Sea divided into two independent water reservoirs-the Big and Small seas-and by July 2002 the water level in the Big Sea had decreased by 22 m (Zholdasova et al. 2002). The dramatic shrinkage of the Aral Sea since the 1960s is one of the greatest environmental catastrophes ever recorded. The salinity of the lake's waters has tripled, killing plant and animal life. In addition, the climate has been affected; both summer and winter temperatures have become more extreme. Plans have been made to use less water from the Amudarya and Syrdarya for irrigation in order that more can flow into the Aral, though these efforts may not be sufficient to save the Aral Sea.

The extreme degradation of the water and deltas of the Amudarya and Syrdarya and the multiple reductions in the area of delta lakes and swamp water areas caused a severe reduction in bio-diversity and a greater concentration of pollution in surface and groundwater supplies. The total area of lakes in the Amudarya delta reduced from 300 000 to 30 000 ha and water mineralisation increased to 20-25 g/l, which resulted in an abrupt reduction of fish and animal reproduction.

In 1960 fish catches in the Amudarya delta weighed a total of 22 520 tonnes compared with only 1 100 tonnes in 2000. Similarly, the water rat population decreased from 1 130 000 to 1 000 (Amirbekov et al. 2002). Between 1970 and 1999 the area of tugay forests in the Amudarya delta reduced ten times from 300 000 to 30 000 ha and no successful attempts were made to restore the natural forest (Bakhiev & Treshkin 2002). Desertification and the degradation of aquatic ecosystems has severely affected wildlife; in the Amudarya delta, besides a reduction in the water rat population, about 6 species and subspecies of fauna disappeared, more than 20 species became rare, and approximately 30 species of ornithofauna disappeared.

Pollution of existing supplies

A considerable part of available (accessible for use) water resources consist of return waters (drained effluents from irrigated areas, industrial wastewaters and municipal sewerage waters). Their average annual volume in the Aral Sea Basin is 32.4 km³ which between 1990 and 1999 increased from 28 to 33.5 km³ (Kipshakbayev & Sokolov 2002, Dzhalalov 2003). Some return waters are used repeatedly for irrigation, more than 51% of return flow is discharged into rivers and 31% into natural relief depressions. More than 95% of the total volume of return waters is formed by drainage waters from irrigated fields, which is the reason why return waters have high mineralisation and are one of the main sources of pollution of surface and groundwater in the region. About 60% of the total volume of return waters is formed in Uzbekistan.

Approximately 15% of surface water supplies in the Aral Sea Basin have been contaminated with polluted drainage and wastewaters (Kipshakbayev & Sokolov 2002). Today, it is severely affecting water quality; mineralisation has increased dramatically, and in some cases has diminished the ecological and economic functions of reservoirs. This is particularly true for the numerous water reservoirs that collect drainage and wastewaters in the lower reaches of the Amudarya and the Syrdarya. The largest of these are the Sarykamysh (with a volume of about 26 km³) and the Aydar-Arnasay Lake (about 30 km³) as well as the Dengizkul, Sudochoye and the Solenoye lakes, each containing several million cubic meters of water. Most of them are stagnating and have

high salinity levels. Subsequently they cannot be used for fishing, and flora and fauna are unable to survive (SPECA 2004).

The mineralisation of the Amudarya water increases from 0.4-0.5 g/l in mountain rivers, to 2.0 g/l or more in the deltas (Chembarisov & Lesnik 1995, Khasankhanova & Abdullaev 2001, Chembarisov et al. 2001a). According to research carried out along the Amudarya and Syrdarya rivers, copper, zinc and hexavalent chromium concentrations exceed the Maximum Allowable Concentration (MAC). Along almost the entire Amudarya River phenol concentrations exceed their MAC. Salinity has increased from 10 g/l to 40-50 g/l due to a lack of freshwater inflow to the rivers.

An average of 11 km³ (36.8%) of return waters are discharged into natural depressions in the landscape and are subsequently not used for economic purposes. The overwhelming proportion of such waters (85.8%) is formed by the drainage waters of the Amudarya Basin. Drainage effluents from irrigated fields discharged into rivers are degrading riverbeds and deteriorating the water quality of the Amudarya. This is adversely affecting the ecology of Priaralye.

The waters of the rivers in the Aral Sea Basin as well as the Aral Sea itself are heavily polluted by salts and chemical pollutants discharged by the agricultural and industrial sectors. These issues are discussed further in the assessment of Pollution.

A major environmental problem facing the Aral Sea Basin is the increasing salinisation of irrigated areas which is reducing their productivity. Soil salinisation is occurring through the use of inadequate drainage systems. Following the collapse of the USSR, a programme of drainage reconstruction and development, and land melioration was significantly reduced, producing a ten-fold cutback in investment. This resulted in increased salinisation and the bogging of lands, and correspondingly a decline in land productivity (ICWC 2004). The high mineralisation of irrigation water is increasing salinisation; for the last 30 years mineralisation in the Amudarya Basin increased from 0.4-0.6 g/l to 1.3-2.0 g/l (Dmitriev 1995).

Between 1990 and 1999, the area of salinised soils increased in the Amudarya Basin from 1.16 to 1.82 million ha (by 57%), and from 0.34 to 0.61 million ha (by 79%) in the Syrdarya Basin. Between 30 and 66% of the total area of irrigated fields in the region are polluted, with concentrations sometimes exceeding the MAC by 20-40 times. The efficiency coefficient of drainage systems between 1990 and 2000 decreased by 30%, and if this trend continues, over 50% of the drainage systems in the region will be out of operation by the mid 21st century.

According to experts, inadequate drainage systems result in annual losses of about 1 billion USD (ICWC 2004). In some areas soil salinity and pollution has caused such a decrease in fertility that irrigation expenses quite often exceed profit and lead to a reduction in product quality (Glazovsky 1995).

The increase in salinised soils has necessitated the further use of water to wash the soils. In Uzbekistan alone it is necessary to wash up to 2 million ha of salinised soils annually, which requires up to 2 million m³ of water per hectare. Annually, total water consumption for these purposes in the region ranges between 6 and 8 billion m³. The process of improving the salinity of soils in irrigated areas would require considerable quantities of water. It is therefore imperative to implement such measures as soon as possible.

Changes in the water table

Total groundwater reserves in the region are estimated at 43.49 km³ per year (Table 8), of which 25.1 km³/year is found in the Amudarya Basin and 18.4 km³/year in the Syrdarya Basin. Over half of total reserves (58%) are located in the Amudarya Basin. The total volume of approved groundwater intake in the Aral Sea Basin is 17.0 km³, of which present-day net intake barely exceeds 11.0 km³/year (Table 8). The greatest groundwater deposits are found in Uzbekistan and Tajikistan (more than 42% of regional reserves).

In the Kazakhstan area of the Aral Sea Basin the majority of groundwater is used for drinking water (more than 68%), compared with about 40% in Turkmenistan and Uzbekistan. In Kyrgyzstan and Tajikistan accessible groundwater resources are predominantly used for irrigated farming, 59.4% and 69.5% respectively.

Water logging and salinisation of soils has resulted in groundwater deterioration. Groundwater levels have changed significantly as a result of abstraction for anthropogenic activities. Declining water levels in the region's rivers and the Aral Sea have affected their ability to recharge

groundwater supplies, resulting in a lowering of the water table by up to 50 cm per year on non-irrigated territories and in some regions by as much as 10-15 m.

On irrigated land, however, the groundwater levels have risen with consequential flooding of populated centres. For example, groundwater levels have increased by up to 1.5 m in 70% and over 50% of the total area of Khorezm oblast and in the lower reaches of the Zeravshan River respectively (Abdulkasimov et al. 2003). According to estimates, about 30% of the irrigation return waters in the upper watershed percolate through the soil to the water table. Some of this water eventually returns to the rivers as saline inflow, but much does not. In effect, much of the water from the Aral Sea has accumulated in the groundwater. As the groundwater is used for irrigation applications downstream, even regions that do not have a high water table are affected. Changes in the biota, unforeseen and often disregarded during the planning of projects, are associated with irrigation causing the water table to rise on an area of 3.23 million ha in the Aral Sea Basin.

Socio-economic impacts

Economic impacts

The freshwater shortage concern is severely impacting the regional economy. The poor quality and lack of freshwater is hindering industries in need of water for operations. In the Aral coastal zone economic activity has been suspended, which is additionally affecting inland industries. The rapid drying-up of the Aral Sea and the associated degradation of its marine ecosystem has led to the collapse of a previously well-developed fishery and fish processing industries. There has consequently been a dramatic decrease in available employment and income for the inhabitants of the Aral Sea region. Since the end of the 1980s in the Kyzylorda region of Kazakhstan and in Karakalpakstan of Uzbekistan, unemployment has been continuously increasing.

A serious consequence of the change in the run-off regime of the main regional rivers is that water is redirected away from pasture lands to fill

Table 8 Groundwater reserves in the Aral Sea Basin and their uses.

Country	Groundwater reserves (km ³ /year)		Used 1999 (km ³)	Groundwater use (km ³ /year)					
	Explored	Approved for usage		Drinking water supply	Industry	Irrigation	Vertical drainage	Experimental pumping	Other purposes
Kazakhstan	1.846	1.270	0.293	0.200	0.081	0	0	0	0.012
Kyrgyzstan	1.595	0.632	0.244	0.043	0.056	0.145	0	0	0
Tajikistan	18.230	6.020	2.294	0.485	0.200	1.594	0	0	0.015
Turkmenistan	3.360	1.220	0.457	0.210	0.036	0.150	0.060	0.001	0
Uzbekistan	18.455	7.796	7.749	3.369	0.715	2.156	1.349	0.120	0.040
Total for the Aral Sea Basin	43.486	16.938	11.037	4.307	1.088	4.045	1.409	0.121	0.067

(Source: Kipshakbayev & Sokolov 2002, SPECA 2004)

lowland depressions, resulting in reduced pasture land. For example, in the area surrounding the Anasay-Aidarkul reservoir more than 2.5 million ha of pasture land has disappeared (Abdulkasimov et al. 2003). Furthermore, desertification resulting from freshwater shortages has also resulted in a reduction of pasture productivity. For the past 15 years pasture productivity in Uzbekistan has reduced by more than 20% and the harvesting of dry mass fed to animals has reduced from 2.4 to 1.8 centner/ha (Abdulkasimov et al. 2003).

A particularly alarming factor is the rapid reduction in the volume of water consumed per capita. According to available data (Kipshakbaev & Sokolov 2002), between 1960 and 2000 water intake per capita in the Aral Sea Basin reduced 1.7 times from 4 270 to 2 530 m³/person and it may reduce to below sanitary standards within the next 20 years if the current rate of population growth continues.

A similar situation exists concerning the distribution of arable lands. Despite a considerable increase in irrigated areas, due to the rapid increase in population irrigated areas per capita reduced almost two-fold between 1960 and 2000 from 0.32 ha per person to 0.18 ha per person (Kipshakbaev & Sokolov 2002). This barely meets the required minimum level for the production of the daily human bread quota (Reteyum 2003). If the current rate of population growth is maintained, four out of five countries in the Aral Sea Basin (besides Kazakhstan and Afghanistan) will reduce the "irrigated area per capita" factor to practically zero over the next 50 years (Rodina 2002).

Water shortage and widespread secondary soil salinity cause a rapid reduction of usable fields and the productivity of agriculture. Thousands of hectares are drying up and becoming salinised. As a result, the current socio-economic and ecological situation in Priaralye is considered to be in crisis (Kamalov 2002). There have been severe economic losses for irrigated farming as a result of freshwater shortages. In the Amudarya Basin, economic losses were approximately 260 million USD in the harvest of 2000 (Sorokin 2002). The most severe situation regarding water supply is observed in the lower reaches of the Syrdarya and Amudarya, resulting in considerable economical losses in Uzbekistan and Kazakhstan.

Increasingly salinised and polluted soils have exacerbated the chemical and biological aggressiveness of the air and water environment. Chemical reagents and microorganisms in the air damage isolators of high-voltage transmission lines and salinised groundwater threatens building and construction foundations. As a result, financial expenses exceed estimated annual investments by 2.8 times (Abdulkasimov et al. 2003).

The most difficult situation is observed in Turkmenistan and Uzbekistan, where 80-90% of the national economy depends on the water resources supplied by transboundary rivers from neighbouring states. Currently the population of Uzbekistan is allocated less than 2 500 m³ of water per person per year, falling short of sanitary standards. If predicted rates of population growth are realised, the situation will deteriorate substantially.

Health impacts

The health impacts of freshwater shortage are considered as severe, as water quality and quantity is directly associated with the spread of disease, especially of the central nervous system, the digestive tract, the vascular system, as well as infectious diseases and immunity deficiency. Health issues associated with the region's ecological crisis include the spread of anaemia, diminished thyroid function, and renal and liver diseases.

Although in general the health of the population in all five countries is relatively good, there has been a deterioration of epidemiological conditions in the region resulting in greater morbidity. Between 1995 and 2003 in Samarkand oblast (Uzbekistan) incidences of disease increased by a factor of 3, the incidence of blood circulation diseases among children increased by a factor of 5, and over the last 8 years the number of children suffering from anaemia increased by a factor of 4. In the Republic of Karakalpakstan, river water is unsuitable for drinking supply for 10 months a year (its mineralisation goes up to 2.5-2.8 g/l of solid residue).

As the Aral Sea recedes it leaves behind a harmful layer of chemical pesticides and natural salts which are blown by the wind into noxious dust storms, seriously affecting the health of the inhabitants of the area. It is estimated that 100 000 tonnes of salt and sand contaminated with pesticide residues are carried away each year by storms with increasing frequency and severity. Cancer and respiratory diseases have subsequently increased in prevalence as well as the rate of infant mortality.

The pollution of surface and groundwater is becoming increasingly alarming and is directly impacting the health of the population. Only water in the run-off formation zone in the mountains, with rare exceptions, meets sanitary standards. Further away from the mountains, the quality of surface and groundwater worsens abruptly and in the lower parts of the river and in the irrigation canals it is regarded as harmful for human health.

Food safety is becoming increasingly alarming due to the lack of potable water for the population located in the downstream sections of the rivers, and famine may occur in future (Rakhmonov 2003). Today, Tajikistan can only provide a quarter of the population with domestically grown agricultural products (Reteyum 2003). If current rates of population growth persist, by the middle of this century the country will experience a catastrophic reduction of arable land per capita, thus jeopardising food security (Rodina 2002).

Other social and community impacts

The sharing of transboundary water resources between the countries of the Aral Sea region can provoke conflicts. There have been increased expenses for deepening wells and pumping and for providing alternative water distribution. The region has witnessed a permanent decrease in agricultural efficiency (including grain crops, livestock, and aquatic crops). The fishing industry, which once employed thousands of people, has practically collapsed. The shores are barren and several villages and large towns, such as Aralsk and Moynoq which were located on the shore before 1960, are now stranded inland.

Due to the water shortage many local populations are choosing to migrate rather than tolerate the unfavourable conditions. There has been an estimated 100 000 people displaced due to the poor environmental conditions in the Aral Sea region. Despite efforts by the governments of the region and the international community, the issue of domestic and economic water supply remains serious and is frequently a subject of political conflict between the nations of the region.

Conclusion and future outlook

In the Aral Sea Basin the irrational use of transboundary water resources is the primary issue affecting the ecological health and socio-economic integrity of the region. Freshwater shortages are severely affecting the welfare of the population and this issue is impeding sustainable development in the countries of the region.

The most prominent impacts of the modification of stream flow and the pollution of existing water supplies are: the modification of riparian habitats; the reduction in agricultural and ecological bio-productivity; depleted fish stocks and a reduction in species diversity, including the extinction of a number of species; a deterioration in water quality of surface and groundwater; a reduction in the extent of wetlands; and the reduced capacity of rivers to transport sediments and disperse pollution. The water table has risen in irrigated areas due to recharge by polluted drainage water, but lowered in non-irrigated areas due to abstraction.

The freshwater shortage concern was assessed as severe, and it can be concluded that surface water resources in the Aral Sea region are fully exploited and the economy of the region is developing under conditions of ever increasing water shortages.

IMPACT Pollution

Many of the rivers in the Aral Sea Basin are contaminated, except in the area of run-off formation. Most pollution consists of various chemical contaminants. The index of water pollution (IWP) is a classification for the pollution levels in the region. The IWP not only takes into account whether the concentration of a substance exceeds Maximal Allowable Concentration (MAC), but also its danger to human health.

Environmental impacts

Microbiological pollution

Poor sanitary standards are evident in the settlements in the Amudarya and Syrdarya deltas. The standard treatment facilities (settling, coagulating, filtration, chlorination) do not offer adequate bacteria removal treatment and in 25-50% of samples the water does not meet national bacterial standards.

Chemical pollution

The excessive application of agro-chemicals has compromised the quality of surface and groundwater supplies. A large number of herbicides, pesticides, mineral fertilisers and defoliant are used every year in the production of cotton, with ecological, social and economic consequences for the region (Chembarisov 1998, Chembarisov & Lesnik 1995, Chembarisov et al. 2001a&b, National report 1998, Myagkov 1991a&b, Myagkov & Miagkova 1998, Isida et al. 1995, IFAS 2000). In the coastal zone surrounding Muinak City, pesticides are applied in quantities ten-fold the average for the former USSR countries, while the total use of pesticides in Uzbekistan exceed the standard level by six times.

The agro-chemicals not utilised by the plants and soil are washed away from the fields and into rivers via irrigation canals. By the end of the 1980s, more than 3 billion m³ of water contaminated with agro-chemicals from the fields of Uzbekistan and Turkmenistan were discharged annually into the Amudarya River (Chub 2000).

A large amount of industrial and domestic wastes has been stored on the territory of the Central Asian countries over a long period of economic activity. The issue of their removal, storage and processing is

becoming increasingly important as they are negatively affecting the environment.

The most polluting industries in Kyrgyzstan are the mining, tanning, cement, chemical, galvanising and textile industries. As the Republic does not have any special facilities to store and process harmful industrial waste, nor sites for their disposal, the industrial enterprises are obliged to store them on their territories.

Until recently, 70 mineral deposits were exploited on the territory of Tajikistan. The mining and processing industries extract huge amounts of mountain rocks and use only 3-10% of these as useful raw material. The rest is stored in tailing dumps and dump pits. Industrial wastes contain over 400 substances, some of them toxic. The main producers of toxic wastes are Tajik Aluminium Plant (TAP), the industrial association "Tajikchimprom," and other enterprises. There are 3 sites for toxic wastes in Turkmenistan: Mariinsk velayat "Karipaty", Lebap velayat "Zerger" and Dashhovuz velayat "Takhta". 1 350 tonnes of out-dated and prohibited chemical pesticides such as keltan, butiphos, metilethylchlorophos were disposed on these sites.

On the territory of Uzbekistan there are 43 enterprises with more than 80 storage sites for industrial wastes. They occupy about 22 000 ha, comparable in size to an administrative district. In Uzbekistan, 300 million m³ of contaminated industrial wastes are produced annually, of which approximately 10% is discharged into water reservoirs without treatment. More than 25 billion tonnes of industrial wastes from mining enterprises, a considerable fraction of which is formed by toxic wastes from non-ferrous industries, have accumulated in the region.

As a result of these economic activities, the rivers of the Aral Sea Basin are generally highly polluted. However, the water quality of rivers in the mountainous regions of the Syrdarya and Amudarya basins is relatively good, though water in the high reaches of some mountainous rivers (e.g. the Pskem, the Chatcal, the Ugam) has a medium level of pollution and a satisfactory IWP (1-3).

Downstream of the mountains the level of river pollution intensifies. Although in some rivers and canals self-cleaning of the water is evident, the general situation of water quality in the Syrdarya Basin is poor and in the lower reaches of the rivers and canals the index of water quality is bad. Water quality is unsatisfactory and contains concentrations of phenols, copper, zinc and chromium higher than their MACs in the rivers of Ahangaran (below the Tuyamuyunskoe reservoir) and Karadarya (near the city of Andijan). Table 9 shows the water quality of the rivers in the Syrdarya Basin.

Table 9 Water pollution in Syrdarya River Basin.

River/channel	Location of the site of water quality assessment	Index of water pollution (IWP)
Syrdarya	5.0 km above the Keles river mouth	3.75
Naryn	0.2 km above the mouth	2.67
Karadarya	5.0 km below the dam of the Andijan reservoir	3.30
Northern Baghdad channel	0.5 km above the mouth	2.97
Tadjigen	0.2 km above the mouth	3.15
Ahangaran	0.5 km above the mouth	3.56
Kyzylcha	At the mouth	1.50
Karasu channel(northern banc)	3.0 km above the mouth	3.55
Chirchik	3.5 km above the mouth	3.81
Akbulak	At the mouth	2.09
Bozsu channel	At the mouth	3.79
Shuruziyac collector	At the mouth	3.03

(Source: Rubinova 2000)

The situation in the Amudarya Basin is no better. The discharge of drainage water results in the deposition of contaminants on the riverbeds. Consequently, mineralisation increases along the course of the River, from 0.7 g/l at the boundary of Turkmenistan and Uzbekistan to 1.7-2.0 g/l at the river delta (Table 10). Furthermore, the salinity of water also increases progressively along the course of the rivers in the Aral Sea Basin (Table 11).

Table 10 Salinity along the Amudarya River.

River	Salinity (g/l)
Upper Amudarya	0.71
Kelif	0.73
Kerki	0.84
Chardjou	0.91
Il'chik	0.98
Tuyamuyun	1.27
Nukus	1.69
Kizildjar	1.92

(Source: Rubinova 2000)

Table 11 Change in salinity along some rivers.

River	Upper river (g/l)	River mouth (g/l)
Amudarya	0.700	2.000
Surhandarya	0.385	1.500
Kashkadarya	0.270	2.500
Zaravshan	0.255	1.800
Karakum channel	0.700	0.900
Syrdarya	0.650	1.800
Naryn	0.250	0.500
Karadarya	0.345	0.520
Ahangaran	0.140	0.660
Chirchik	0.190	0.500

(Source: Rubinova 2000)

According to sanitary research the amount of chemical pollutants discharged every year into the Amudarya amounts to 300 tonnes of oil products, 1.35 million tonnes of sulphates, and 19 000 tonnes of surface-active substances. Similarly, 23 000 tonnes of oil products,

787 000 tonnes of sulphates, 925 000 tonnes of chlorides, 5 tonnes of phenols and 7 tonnes of surface active substances are discharged into the Syrdarya every year. In certain sections of the Amudarya (Temirbai) and the Syrdarya (Kyzylorda and Kazalinsk) mineralisation of water between the early 1930s and the late 1980s has increased by 2-3 times. In the Aral Sea, until the year 2000, mineralisation increased 5-6 times compared to the beginning of the 1960s. Today, the rate of mineralisation in the rivers is static. The mineralisation trends at the main sections of the Amudarya and Syrdarya basins during the last 6 decades are given in Table 12.

Table 12 Historical changes in salinity in some rivers in the Amudarya and Syrdarya basins.

River	Salinity (g/l)					
	1932-1950	1951-1960	1961-1970	1971-1980	1981-1990	1991-1999
Amudarya Basin						
Surkhandarya - Zhdanov - Manguzar	0.3-0.57	0.32-0.6	0.35-0.88	0.38-1.08	0.40-1.2	0.42-1.2
Amudarya - Kerki - Samanbai	0.5-0.51	0.51-0.52	0.57-0.64	0.59-0.75	0.57-1.2	0.57-1.2
Kashkadarya - Varganza - Karatikon	0.26-0.38	0.27-0.49	0.28-1.01	0.3-1.82	0.31-2.57	0.35-2.57
Zeravshan - Dupuli - Navoi	0.22-0.3	0.23-0.55	0.24-0.73	0.24-0.88	0.24-1.22	0.25-1.22
Syrdarya Basin						
Naryn - Toktogul - Uchkurgan	0.24-0.28	0.24-0.29	0.25-0.29	0.25-0.3	0.26-0.3	0.26-0.3
Karadarya - Uchtepe - Kampyravat	0.3-0.48	0.31-0.49	0.32-0.5	0.35-0.52	0.40-0.53	0.42-0.53
Chirchik - Khodjikit - Chinaz	0.17-0.34	0.18-0.4	0.18-0.44	0.19-0.65	0.23-0.72	0.25-0.72
Angren - Turk - Soldatskoie	0.12-0.32	0.13-0.33	0.13-0.44	0.13-0.68	0.13-0.85	0.13-0.85
Syrdarya - Kal - Kyzylkishlak	0.4-0.42	0.45-0.59	0.62-1.03	1.04-1.2	1.1-1.25	1.12-1.26

(Source: Rubinova 2000)

In the region around the city of Nukus, the waters of the Amudarya River are contaminated with heavy metals, hexachloran, sodium and magnesium. At the section of Kyzylzhar, pesticides are 20-30 times the MAC and the water is classified as dangerous.

The discharge of wastewater causes a rapid deterioration in the ion composition of the river water. Thus, at the narrowing of the Kyzylzhar River, concentrations of calcium ions increase by 240%, magnesium by 420%, hydrocarbons by 120%, sulphates by 620% as compared with the zone of run-off formation. One of the most polluted rivers is the Zeravshan. Mineralisation of water in this river increases from 0.27-0.30 g/l at the headwaters to 1.5-1.6 g/l at the estuary and concentrations of pesticides exceed the MAC by 5.8-6.2 times. High concentrations of antimony have also been detected which implies grave health implications for the population. Water in the lower section

of the Zeravshan River is classified as dangerous. Over the past few years increases in concentrations of sulphate and chloride and magnesium and potassium have been recorded (Chub 2000).

According to research only 8% of water in Uzbekistan are categorised as polluted or very polluted, but 25% are moderately polluted, i.e. they are at the "red line" which determines a conventional boundary between satisfactory and unsatisfactory water quality. The water bodies in Uzbekistan have a total area of 173 600 km², of which 8.6% is classified as good quality water, 35.2% as satisfactory, and 44% as bad quality water. In addition, 5.2% of the country's water quality is classified as harmful for human health and in 7.2% very harmful. Only 2.3% of the population live within the area of good water quality, yet more than 49% live in the areas of bad water quality, 2.4% use harmful and 0.2% use very harmful water (Chembarisov et al. 2001a&b).

Fortunately, only background concentrations of heavy metals and oil products are observed in the majority of the region's rivers, and most pollution is concentrated around industrial and urban conglomerations. The discharge of heavy metal compounds, chlorine and organic pesticides into the Aral Sea has resulted in the mortality of game-fish, fish tumour diseases, and changes in cytogenetic parameters. In 1970 maximum levels of oil hydrocarbons were recorded in the Aral Sea. However, since 1978 recorded pollution from oil hydrocarbons has been within the national standards (Chembarisov et al. 2001a&b, Myagkov & Myagkova 1998, Bragin et al. 2001).

Solid waste

Billions of tonnes of solid industrial wastes have been stored in Kazakhstan. The non-ferrous industry was responsible for more than 5.2 billion tonnes of wastes, of which 4 billion tonnes are stored in the waste disposal sites of the mining industry, the ore-dressing industry more than 1.1 billion tonnes and metallurgical processing 105 million tonnes of waste.

Radionuclides

The level of radiation contamination in the region varies relatively little. The dosage rate of gamma radiation ranges between 5-25 mR/hour, with an average value of 14.4 mR/hour. The density of precipitation of beta-ionising radionuclides from the atmosphere ranges between 0.5 Bq/m² per day in Kazakhstan to 5.0 Bq/m² per day in Uzbekistan, the average value for the region was 2.6 Bq/m² per day (excluding Tajikistan).

Socio-economic impacts

Economic impact

Pollution is currently one of the most pressing issues in the region and its impact on the economy was assessed as severe. There is a lack of effective preventative measures to tackle the problem of pollution and its consequences. Pollution has had significant impacts on industrial development, competition and investment within the regional economy.

The economic impacts of pollution in the region include: increased expenses for animal protection; loss of economically important species; a decline in the productivity of agricultural land; and the cost of remediation programmes. Commercial fishing in the Aral Sea, which peaked in the 19th century when more than 40 000 tonnes of fish were caught annually, had almost ceased operations by the beginning of the 1980s as a result of increased water mineralisation and pollution (Glazovsky 1995, SPECA 2004).

One of the most alarming consequences of the irrational use of land and water resources is the degradation of arable lands. This has resulted primarily from increasing soil salinity and contamination due to the excessive application of herbicides and fertilisers. Nowadays, out of a total of 7.8 million ha of irrigated land in the Aral Sea Basin, more than 50% has experienced increased salinisation. In the last 20 years humus concentrations, the main factor determining soil fertility, has reduced by at least 40% (Abdulkasimov et al. 2003).

In Uzbekistan, moderately and severely salinised soils increased by more than 50% and by 80% in the irrigated areas of the Fergana valley (Glazovsky 1995). More than 30% of irrigated land is salinised in Tajikistan, up to 40% in Kyrgyzstan (Khamidov 2002) and in Turkmenistan as much as 95% (Yermolov 2003). As a result of soil salinisation and contamination, the productivity of the main agricultural products - grain crops, vegetables, cotton and berries - has decreased since the 1980s. Even with minimal soil salinisation, cotton productivity can decrease by 50-60%, barley by 30-40%, corn productivity by 40-60%, and wheat by 50-60% (Askarova 2002). Total reduction in crop yield from irrigated areas caused by soil salinisation was 30% in Uzbekistan, 40% in Turkmenistan, 18% in Tajikistan, 30% in Kazakhstan, and 20% in Kyrgyzstan (Abdulkasimov et al. 2003). In addition, the productive quality of irrigated lands in Central Asia is declining due to toxicants deposited by contaminated water being washed onto the low-lying areas of the region.

Health impacts

There has been an increase in the rate of morbidity and the spread of disease in the region. Populations residing within the coastal zone of

Kazakhstan and Uzbekistan have experienced a permanent increase in respiratory, infectious and internal diseases (Khasankhanova & Abdullaev 2001).

The issue of deteriorating water quality is having a detrimental impact on the health of the population of the Aral Sea Basin. This is most prominent in the lower reaches of the Amudarya and the Syrdarya, especially in the ecologically unstable territory of Priaralye. Serious health problems concerning the population of Priaralye were registered at the end of the 1980s (Rudenko 1989). The mineralisation of drinking water was equal to 2-4 g/l and bacteria exceeded MAC by 5-10 times. By the end of the 1980s the health of the population in the region had reduced dramatically; 60% of the local population examined had serious health problems, 80% of pregnant women suffered from anaemia, and cases of infant mortality were 82 per 1000 children born alive (Glantz 1998; Rudenko 1989). The incidence of tuberculosis, mortality from infectious and parasite-caused diseases as well as infant mortality is much worse in Priaralye than in the rest of the region. From the 1970s to the 1980s the death rate in different areas of Priaralye increased by a factor of between 3 and 29 (Tsukatani 1998). In addition, pests are abundant in the desert zone of Priaralye and act as a vector for diseases. For example, in 1999, 4 cases of plague and two cases of Crimean gemmorological fever were registered in Kyzylorda oblast (Tokmagambetova 2000).

A major factor causing the high level of morbidity is the mineralisation of drinking water and the high concentrations of chemical fertilisers, pesticides and defoliants introduced into cotton fields, such as the DDT, methyl mercaptophos, ostametyl, dutifos, milbex, hexachlorane, lenacil, and ronit (Ro-Neet), Yalan which are contaminating surface and groundwater supplies and the atmosphere.

Furthermore, the disinfection of drinking water using chlorine causes the formation of the highly hazardous organo-halogen compounds in concentrations that exceed local health standards 2-4 times. The genotoxicity of mother's milk, revealed in the urban areas of Nukus and Turtku, is likely connected with the use of chlorinated water.

These pollutants are also contaminating food products. As early as the mid 1980s pesticides, mineral fertilisers, various microorganisms and their toxic derivatives became the main pollutants of food products in Kazakhstan and particularly in Priaralye (Sharmanov 1998). Analysis of different fish species caught in the Syrdarya delta showed an increase in the concentrations of insecticides and heavy metals in their organs and tissues.

Increased concentrations of lead, cadmium and manganese have been found in children's organisms, resulting in considerable damage to the functions and structure of their cells. The number of people suffering from oncological diseases is increasing at an alarming rate. For example, in Kyzylorda oblast 800 people reportedly suffer from oncological diseases every year; primarily from oesophagus cancer (46.6 cases per 100,000 people) and stomach cancer (Tokmagambetova 2001). A significant correlation (0.80-0.99) between the salt composition of drinking water and the number of oncological oesophagus diseases has been established.

Poor quality drinking water is recognised as a major factor for the high morbidity rate in the region. This conclusion is supported by the data of figures 6 and 7, which show a correlation between the percentage of infant mortality and mortality from infectious diseases in Karakalpakstan and Khorezm oblast (data presented by the Public Health Ministry of Uzbekistan) and the disparity of water quality from the standards of Uzbekistan (Khasankhanova & Abdullaev 2001). A deviation in water quality from the standards by only 25% causes an increase in mortality from infectious diseases by 25 to 60 cases per 100 000 people (Figure 6). As the deviation from water quality standards increased from 20% to 80%, infant mortality increased from 18-20 to 50-55 per 1 000 live births (Figure 7).

In the majority of the Aral Sea Basin sanitary conditions are similar. For example, in Kyrgyzstan, where in general the ecological situation exceeds that of Priaralye, the sanitary-epidemiological situation is relatively poor. Every year more than 200 000 cases of infectious diseases are registered in this republic. The number of reported cases of acute intestinal infections (20.4% in 2000) and hepatitis (9.3%) is also very high, especially in the areas with an insufficiently developed central water supply network. The main reason for this situation is poor water quality, with drinking water receiving inadequate treatment. About 36% of water supply sources in the republic have inadequately wide sanitary protection zones, more than 8% of water supply receives no treatment and more than 60% of water does not pass preliminary disinfection. Overall 700 000 residents (1/6 of Kyrgyzstan's population) are not connected to the central water-pipe network. The unsatisfactory state of rural water-pipes obliges the population to use water from surface water reservoirs and irrigation systems (Vashneva & Peredkov 2001).

As a consequence, the incidence of acute intestinal diseases is very high in Kyrgyzstan. The sanitary-epidemiological situation in the Osh oblast is particularly alarming, due to it having the fewest number of houses with access to running water in Kyrgyzstan. The incidence of common intestinal diseases in Kyrgyzstan (382.2-637.7 per 100 000 people

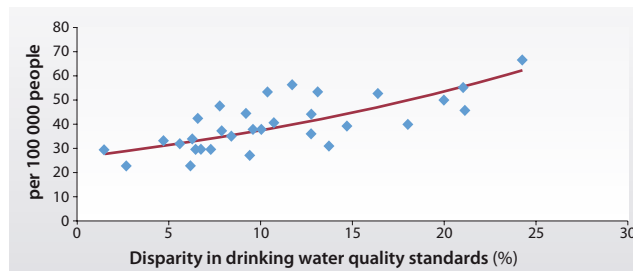


Figure 6 Correlation between mortality from infectious diseases (per 100 000 people) and a deviation of water quality from the accepted standards.

(Source: Khasankhanova & Abdullaev 2001)

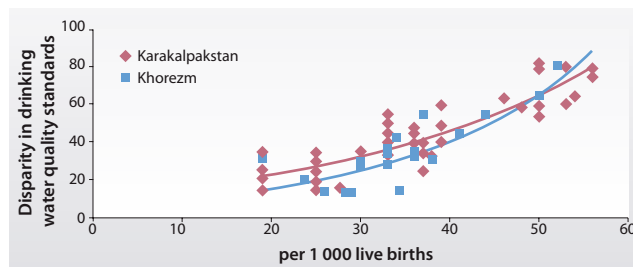


Figure 7 Correlation between infant mortality rate (per 1 000 live births) and a deviation of water quality from the accepted standards.

(Source: Khasankhanova & Abdullaev 2001)

between 1990 and 1999) is often greater than that of Priaralye. During the last decade only in Kyzylorda oblast did cases increase more persistently than in Kyrgyzstan. Cases of enteric fever have been recorded in Kyrgyzstan and in 1998 there was an outbreak of enteric fever with 1 200 cases (Vashneva & Peredkov 2001).

The declining quality of the region's water resources has been a primary cause of the deterioration in the health status of the region, but socio-economic factors and the general degradation of the region's environment have also played an important role. Since the beginning of the 1990s, higher unemployment, a reduction in family income and associated poverty and unbalanced nutritional intake, combined with a degrading medical service have undoubtedly affected the health of the region's inhabitants.

Other social and community impacts

Many communities have lost the recreational and amenity value of their local environment due the reduction in species diversity. The social and cultural integrity of communities in the most affected areas has been threatened by the deterioration in the environmental quality of the region. Pollution has led to a loss of ecosystem services resulting in increased unemployment, greater prevalence of diseases and economic hardship. The quality of agricultural products, and subsequently their nutritional value, has been reduced. Governmental support has been required to assist the public and implement remediation measures.

Overall, other social and community impacts of pollution were assessed as moderate.

Conclusion and future outlook

Overall pollution was considered as severe. The issue of chemical pollution has the most devastating transboundary impacts. The excessive application of agro-chemicals is compromising water quality as drainage water from the irrigated fields is discharged into surface water and leaches into groundwater supplies, thus increasing mineralisation and salinity, particularly in the lower reaches of the rivers. Industrial, mining and domestic waste is inadequately disposed and contaminates aquatic ecosystems. Pollution is hindering economic development and increasing the prevalence of disease. Unless effective measures are established and adhered to, the extent of pollution in regional surface and groundwater is expected to increase in the future.

Habitat and community modification

Large-scale irrigation projects, particularly for cotton production, have resulted in significant habitat modification, especially in the vicinity of the drying Aral Sea. The ecosystems of the Sea have been severely degraded, particularly those of the Syrdarya and Amurdarya river deltas. Habitat modification has been largely caused by the diversion of freshwater resources for irrigated farming and the pollution of existing water supplies, and therefore this concern needs to be considered with the freshwater shortage concern.

Environmental impacts

The drying-up of the Aral Sea has resulted in: a more arid climate, with an intensification of desertification; increases in groundwater mineralisation and the salinisation of soils; greater wind-blown salt and dust from the dried-up sea bottom; and a sharp reduction in biodiversity. The Syrdarya and Amurdarya deltas have suffered the greatest impacts. The area of natural lakes in the Amudarya and Syrdarya delta were reduced from 640 and 833 km² to 80 and 400 km², respectively. Alluvial-meadow and marsh-meadow soils were transformed into meadow-takyr and meadow-desert soils. Over 1 million ha of flood-lands have dried-up and the productivity of reeds has decreased by a factor of 30-35. The area of Tugai forests was reduced by almost 90% as a result of reduced water availability. Consequently, 18 species of higher plants were lost, and 54 species of higher plants are now threatened with extinction, including relict and endemic plants. The degradation of nesting sites resulted in a severe reduction in bird fauna in river deltas from 173 to 30

species (Amirgaliev & Ismukhanov 2002, Ashirbekov et al. 2002, Askarova 2002, Bakhiev & Treshkin 2002, IFAS 2000, Novikova 1999, Novikova et al. 2001).

Changes to the Aral Sea ecosystem

The reduction of the water inflow to the Aral Sea has resulted in irreversible changes to the Sea's hydrological and hydrochemical characteristics and its ecosystems. The changes in the saline balance have trebled the salinity, and subsequently transformed the Aral Sea into a biological desert.

The early 1980s witnessed great changes in water fauna. The freshwater and brackish water fauna, for example phytoplankton and zooplankton species, were replaced by more salt-tolerant marine and haline species. There has been a four to five-fold reduction in microorganisms (bacteria and yeast) that inhabit the waters and saline sediments. The population and biomass of the phytoplankton decreased three to five-fold, and was replaced by diatom algae. The diversity of zooplankton was also impoverished, but its biomass remained at a similar level. Even more striking shifts were observed in the macro-zoobenthos. In the late 1970s, colonising marine species from adjacent saline waters practically replaced the indigenous species. 44 species existed in the benthos in 1970, 15 in 1978, and 32 in 1982. When the mean salinity of the sea exceeded 17‰, only 9 species remained from the native fauna (Aladin & Kotov 1989, Aladin et al. 2001).

The ichthyofauna of the Aral Sea has undergone considerable changes. The addition of colonising fish has increased the number of fish species from 20 to 34. Previously the dominant species were freshwater fish, including bream, sazan, vobla (Caspian roach) and harbel. The continuing salinisation of the sea has not favoured reproduction, resulting in decreased catches (except of pike, perch and chub). In the early 1960s the fish catch in the Aral Sea was 46 000 tonnes per year (over 15% of the total freshwater catches in the USSR), of which nearly 70% was large fish. By 1970 annual catches had fallen from 41 000 to 10 000 tonnes and in the early 1980s the total catch had fallen to 1 000 tonnes. Nowadays fishing has practically ceased altogether (Aladin 1999).

An increase in salinity to over 23‰ has led to the brackish water Caspian invertebrates dying out or retreating into the delta waters. The only survivors were the marine forms and salt-tolerant hydrobionts, which arrived in the Aral Sea from hypersaline waters. In recent decades the invertebrate fauna has consisted exclusively of colonising species, the majority of which have remained untouched due to the exhaustion of fish stocks. Today, salinity in the Big Aral Sea is nearly

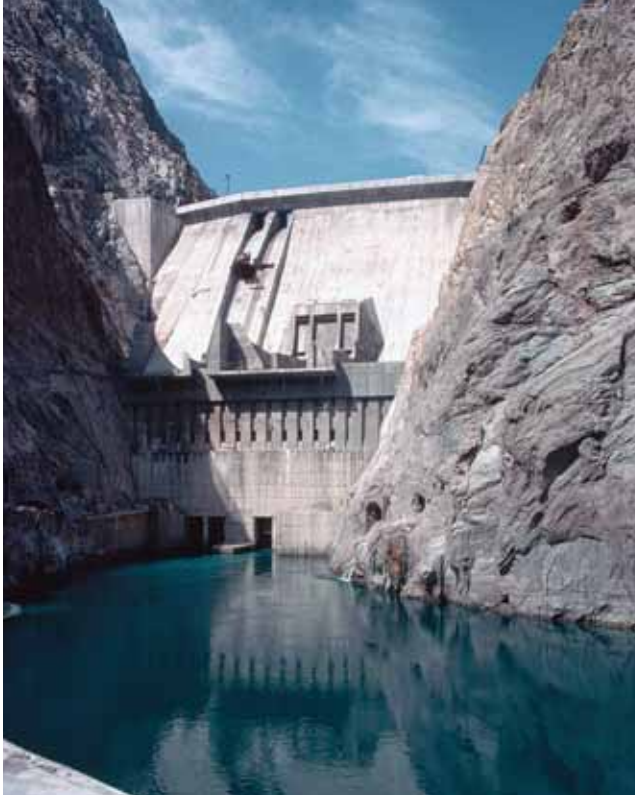


Figure 8 The Toktogul hydroelectric dam on the Naryn (Syrdarya) River, Kyrgyzstan.
(Photo: CORBIS)

63‰ and consequently very little is able to survive in these waters (Zholdasova 1999).

The drained tract of the Aral Sea Basin is characterised by a lower biodiversity in comparison with the coast. Among the plant species of the Aral Sea coast, 30 species are valuable fodder plants, there are more than 30 species of medicinal plants and 31 species of weed plants. More than 60 species of local flora are potential phytomeliorants for the dried coasts (Novikova 2001).

The area affected by irrigation practices is not restricted merely to the land which is actually irrigated but instead includes the feed source (the river), the reservoirs, the main and subsidiary canals, the man-made lakes (for accumulation of the collector-drainage waters) and the river valleys, deltas, and final lakes. All these components of irrigation cause significant changes in the region's terrestrial and aquatic ecosystems (Bakhiev & Treshkin 2002, Novikova 1999, Novikova et al. 2001, Treshkin 2001).

The development of irrigated agriculture in the Aral Sea Basin has replaced natural desert ecosystems of an area of 7.2 million ha with

agricultural coenoses. To regulate water feed to the fields, reservoirs (Chardara on the Syrdarya River; Takhiatash and Tyuyamuyun on the Amudarya River) were created, inundating 277 000 ha of floodplain and desert ecosystems. Furthermore, canals were created, destroying 40 000 ha of the natural environment. The total length of the irrigation and drainage channels in Uzbekistan is 180 000 km. Thus, as a result of irrigation development over the last 30 years, approximately 4.5 million ha of natural ecosystems have been lost, with a total biological productivity of 5.4 million tonnes (including 1.8 million tonnes of useful products). The total biological production of the agro-coenoses on irrigated areas is 120 million tonnes, 10 million tonnes of useful production (Kuksa et al. 1991).

Changes in the biota, unforeseen and often disregarded during the planning of projects, are associated with raising the water table by irrigation. In removing the collector/drainage waters from the oases, 530 000 ha of desert ecosystems have undergone flooding, waterlogging and salinisation. Thus, as a result of the processes accompanying irrigation, salty solonchak-type ecosystems have developed on an area of 4.06 million ha, where weedy halophile mixed herbs and halophile shrubs and sub-shrubs dominate, with an impoverished diversity of fauna. Remembering that about half of the present irrigated lands have become saline and parts of them are not sown every year, the total area of anthropogenic solonchak systems approaches 5 million ha.

A change in the water balance of the rivers and increased water mineralisation has resulted in the loss of unique biocenosis and a number of endemic animal species. Until 1960 over 70 species of mammals and 319 species of birds inhabited the river deltas. Nowadays these numbers have been reduced to 32 species of mammals and 160 species of birds. In the low-lying areas of Syrdarya more than 100 000 ha of alluvial soils have become alkali soils and more than 500 000 ha of wetlands have dried up. This has resulted in the modification and destruction of 5-7 food sources for sheep, goats, horses and camels (Saiko 2000).

Changes to the wetland (tugai) ecosystem

Syrdarya delta

The ecological changes to the Syrdarya delta began slightly earlier than in the Amudarya delta. As early as the 1960s, the renewable water resources of the Syrdarya Basin were fully exploited, and in the 1970s this level was exceeded as return waters also began to be exploited. The further increase in river-water abstraction led to a reduction in flow in the lower reaches of the delta. In the late 1970s, only an average of 4% of the annual resources formed in the catchment area actually

entered the Syrdarya delta. The summer-spring floods on the Syrdarya ceased as early as 1971. Simultaneously, there was a rapid fall in the level of the Aral Sea, which led to desertification on the delta plain. By 1978 approximately 114 000 ha of alluvial meadow soils had turned into solonchaks and 532 000 ha of marshy and meadow-marshy soils had dried out and 31 000 ha had become desert. Thus, 732 000 ha effectively went out of agricultural use. The productivity of the grass/mixed-herb and mixed-herb meadows was reduced to one-third of its former level (Bakhiev et al. 1987).

Formerly rich areas of hydrophile vegetation (hay and fodder areas) died on a large part of the delta. Total fodder resources fell from 1.5 to 0.5 million tonnes. The area of riparian woodland was halved, and the remaining was severely degraded and desertified. Desert species of plants and animals started to expand in the delta and floodplain, and impoverished desert ecosystems began to form (Novikova 1999). Colony-forming birds relocated away from the lower reaches of the Syrdarya.

Amudarya delta

The reduction in river flow following the construction of the Takhiatash and Tyuyamuyn reservoirs and the excessive use of water in irrigated areas has modified the delta and floodplain environment. The area occupied by plant communities found in the floodplain habitats only under annual spring-summer flood inundation was reduced from 35% to 8% and plant communities characteristic of periodically flooded habitats above the floodplain were reduced from 40 to 20%. At the same time, the number of communities associated with salinised and desertified parts of the floodplains and delta rose from 25 to 75% (Novikova 1999).

Vast reed thickets occupied more than 300 000 ha in the Amudarya delta. They were a rich habitat for bird fauna, inhabited by 21 species of waterfowl (including 11 nesting species, the Khivin pheasant, 9 species of waders, including spoonbills), several species of raptors and more than 10 species of passerine birds. Wild boar and reed cat were widespread and until the late 1930s the Central Asian tiger inhabited the flood plains. By the mid 1980s the area of reed thickets had reduced five-fold, and the green weight yield decreased from 30 000-40 000 kg/ha in the 1960s to 4 000-12 000 kg/ha in the 1980s. The populations of reed dwelling animals were considerably depleted. By the 1980s the wild boar population had declined almost six-fold (Kuksa et al. 1991).

In the maritime area of the delta, a large muskrat population inhabited lakes. In the early 1980s this whole network of lakes had dried up, putting an end to hunting and trade. The muskrat continued to be

caught on a non-commercial scale until 1990 on Lakes Togus -Tore and Sudochoye.

With the persisting and worsening aridity and desertification of the environment in the Amudarya river delta, the productivity of the meadow and pasture communities continues to decline in the current environmental conditions of the Aral Sea region.

Desertification in the delta is leading to the replacement of highly productive reed communities by mixed communities of low growing reed, annual *Salsola* spp., often by bushes of tamarix and in some places by *Karelinia caspica* and *Alhagi pseudalhagi*. The yield of these communities does not exceed 400-500 kg/ha. By 1985 only 70 000 ha of watered reedy hay lands remained in the Amudarya delta. Commercially valuable reed areas can only be preserved by irrigation on the bottom of the drying up lakes and depressions between the streambeds for about 2 months a year.

The increasing aridity of the Amudarya floodplain and delta, and the practice of unsustainable forestry have threatened the existence of the unique riparian woodland ecosystems. In the early 1930s the riparian woodlands occupied 300 000 ha in the lower reaches of the River, but by 1986 this had been reduced to 33 000 ha. In 50 years their area within the lower reaches and Amudarya delta had decreased by nearly 90%. The degradation and loss of the riparian woodlands gained impetus in the late 1970s and 1980s. In 8 years (1978-1986) the area of riparian forests in the delta halved. The rate of mortality of the riparian woodland reached a "record" of 5 778 ha per year. Today these forests form less than 3% of the total forest resources of Karakalpakstan. Many of the stands that have persisted are now dying, and illegal felling continues (Treshkin & Kuzmina 1993).

Floristically the Amudarya riparian forests are the richest ecosystem in Central Asia and include 567 species of higher plants, including 29 endemic species and many relict plants of the Tertiary geological period. Presently, the profound disruptions in habitat have led to the near extinction of 54 species of plants (in 46 genera and 26 families). Even by the end of the 1980s, white and yellow water-lilies, *Aldrovanda*, *Agropyrum repens*, and ferns no longer existed (Novikova 2001).

The number of mammals has declined. The Khangul-Bokhara deer, the typical inhabitant of the riparian woodlands, has virtually disappeared from the wild. Only about 10 semi-wild deer in the Baday-Tugai reserve survive today.

Environmental degradation has resulted in a reduction in the trophic potential for birds and mammals. The fish mortality in the Aral Sea and the impoverishment of food sources in the delta waters makes survival difficult for fish of higher trophic levels and insectivorous birds of the water-swamp ecosystem.

There was widespread migration of waterfowl and aquatic-swamp birds both within the Aral Sea region and further a field. As early as 1978, a complex of birds including thousands of red-legged and red-crested pochards and river ducks, whooper swans, spoonbills, cormorants and white and Dalmatian pelicans left the Syrdarya delta, which had lost its flooded areas, and migrated to the Turgai lakes, 350-400 km north. The total number of species which relocated amounted to several hundred thousand (Zaletaev 1989).

Socio-economic impacts

Economic impacts

The impacts caused by habitat and community modifications affect practically all economic sectors. Considering the significant and continual damage caused by this concern, and the high gravity of the consequences, economic impacts were assessed as severe.

Changes in vegetation caused a reduction in pasture productivity from 1.2 million to 600 000 tonnes, and the productivity of cereal mixed-grass meadows and mixed-grass meadows decreased three-fold. Commercial use of water-marsh areas has ceased completely (Kuksa et al. 1991).

Desertification led to a decline in the areas of hay and pastures and a reduction in their yields. Since 1960, the area of hay was reduced from 420 000 ha to 70 000-75 000 ha by the end of the 1980s. Along with this 6-fold reduction in area, the hay yield on the periodically watered areas fell from 1 500-4 000 to 300-1 600 kg/ha (dry plant weight) and to 70-80 kg/ha on the non-watered desertifying areas. Only a third of pastures in the Amudarya delta remained, falling from 348 000 to 120 000 ha, and pasture productivity fell from 100-1 400 to 50-500 kg/ha. The reason for the sharp fall in biological productivity of the meadow communities in the Amudarya delta was the reduction in water supply to the terrestrial ecosystems by 3-4 classes according to Ramenskii's scale, from moist-meadow to dry-steppe and desert (Novikova et al. 1998 & 2001).

In the Syrdarya Basin the commercial potential of the water-marsh areas was lost. In the 1950s the yield of muskrat skins was 70 000 to 230 000. In 1968 this figure was reduced to 9 000 skins, and by 1978 only 72. There is now no muskrat trade (Kuksa et al. 1990).

In the Aral Sea itself, salinisation has led to a severe decline in the fisheries. Fish catches fell from 46 000 tonnes in the early 1960s, to 10 000 tonnes in the 1970s and by the 1980s only 1 000 tonnes were landed. Today, the fisheries industry has practically collapsed (Aladin 1999).

Health impacts

Habitat and community modification has had detrimental effects on the health of the population. In areas where severe habitat modification has occurred, living conditions have deteriorated, and subsequently incidences of anaemia, diminished thyroid function, and renal and liver diseases has increased. The morbidity rate over the last 10-12 years has been permanently rising and this trend is predicted to continue. The decline in productivity of the regional ecosystems has reduced their nutritional value for humans, for example, from pasture lands and the fisheries. The health impacts associated with this concern were assessed as severe.

Other social and community impacts

The population of the region is now forced to survive upon poor quality and scarce food supplies. The ecosystems have lost their assimilate capacity for human activities, and it has become difficult to utilise alternative territorial resources without inflicting further environmental degradation. The employment structure has changed as individuals are forced to adopt alternative livelihood strategies due to the collapse of traditional industries, such as the fisheries. There has been a loss in the cultural and recreational value of the natural environment for the communities of the region. The impacts are occasional but long-term, and the degree of gravity is medium. Overall, other social and community impacts were assessed as severe.

Conclusion and future outlook

The modification of habitats has been severe in the Aral Sea region. However, it is primarily a function of freshwater shortage rather than a result of direct habitat modification by humans. For example, the loss and modification of the habitats associated with the Aral Sea and the river deltas is attributed to the reduction of stream flow as a result of water abstraction for irrigation purposes. This concern was therefore not selected as the region's priority concern despite its severe environmental and socio-economic impacts.

The intensity of anthropogenically induced desertification, secondary soil salinisation and destruction of the region's biodiversity, especially in Priaralye, has not decreased in recent years. Since the end of the 1980s no research has been carried out in the zones of run-off formation, and there is little information available on the degradation of mountain ecosystems (i.e. concerning reductions in the area of woodland

vegetation and intensive erosion). Furthermore, the recreational amenity provided by the mountain regions is being developed; if this is not sufficiently regulated there may be ecological consequences. According to GIWA experts, besides developing a network of protected areas for conservation in all countries of the region, the rehabilitation of degraded ecosystems necessitates the establishment of national and regional ecological programmes aimed at evaluating ecosystem degradation and understanding the dynamics of natural processes in order to identify the impacts of development trends and future proposals.

Unsustainable exploitation of fish and other living resources

The fishing industry has practically collapsed in the Aral Sea Basin. Annual fisheries production declined from 46 000 tonnes in the early 1960s to 1 000 tonnes in the 1980s and today very little fishing is practiced. There have also been significant changes in the taxonomic composition and diversity of fish species. For example, freshwater species have been replaced by more salt-tolerant marine and haline species. However, this has not been the result of the unsustainable exploitation of fish and other living resources, but resulted rather from the habitat and community modification concern. This in turn has been driven by the diversion of water for irrigated agriculture, which has prevented the sufficient allocation of water for the downstream habitats of fish and other aquatic organisms.

Environmental impacts

The former thriving ecosystem, which supported 24 game fish species, has been severely impoverished. Fish species included carp, grouper, sturgeon, salmon, met sheat-fish and sea-pike. The fishing industry was based primarily on the three fish species: bream, carp, and Aral dace. In the Aral Sea, the valuable fish species of sawyer and white-eye fish were fished near the coastal areas and in the lower reaches of the rivers. Changes in the saline structure of the Aral Sea and a loss of biota have resulted in the collapse of the fishing industry in the Sea by the year 2000, although some fishing still continues in the water bodies of the Syrdarya and Amudarya basins.

Since the mid-1970s members of the Aral department of Kazakhstan Scientific and Research Institute of Fisheries have conducted research into salt-affected fish species, including Caspian sturgeon, kurin salmon, azov and chernomor plaice-gloss and plaice-calcan. With its high ecological plasticity and ability to spawn in water with a salinity level of 17-60‰, the plaice-gloss has proven the most successful species to survive in the

current physical conditions. Today, the plaice-gloss accounts for more than 30% of the total amount of fish caught in the Aral Sea.

Socio-economic impacts

Economic impacts

The decline in the fisheries has impacted the economy of the region due to the importance of the industry to many communities. The impact on the regional GDP from the collapse of the fishing industry can be assessed as medium to high. However, it should be noted that the economic impacts have been primarily a result of environmental changes rather than the overexploitation of fish.

Health impacts

This concern has limited direct affects on the health of the population, and there is consequently limited available data.

Other social and community impacts

Fishers surrounding the Aral Sea have been forced to migrate or change their livelihood strategy as the Sea receded. The communities have lost a valuable source of nutrition and income, in addition to the loss of many other ecosystem services. Consequently, the quality of life for these communities has been diminished.

Conclusion and future outlook

GIWA experts agreed that the concern of unsustainable exploitation of fish and other living resources is irrelevant and non-applicable to the region under the current freshwater shortage scenario.

The restoration of marine biota may be possible following the construction of the Kokaral Dam which will considerably raise the water level of the Small Sea. Opportunities to improve the ecological situation in the critical zone of Priaralye, as well as in the entire basin, are dependent on freshwater availability and the allocation of water. In order to rehabilitate the fisheries water needs to be equitably distributed, the sea level needs to be regulated and sufficient minimum discharges from the Amudarya and Syrdarya need to be maintained.

Global change

Environmental impacts

Changes in the hydrological cycle

Variations in precipitation and temperatures

The recession of the Aral Sea has, to a certain extent, changed the climate of the Aral Sea region (Molostnova et al. 1987, Zolotokrylin &

Figure 9 Beached boat in a part of the Aral Sea which was once covered in water.
(Photo: SPL)



Tokarenko 1991, Zolotokrylin 2003). Summer and winter air temperatures at measuring stations near the shore have increased by 1.5-2.5°C and diurnal temperatures have increased by 0.5-3.3°C. At coastal stations the mean annual relative air humidity decreased by 23%, reaching 9% in spring and summer. The number of days the region experienced drought increased by 300%.

The annual cycle of precipitation has also changed. In 1959 maximum precipitation fell during February and March and the minimum in September, whereas between 1970 and 1979 the maximum was observed in April and the minimum in July. A three-fold increase in reflected solar radiation in the Aral area due to a seven-fold rise in the albedo of the area previously occupied by the Aral Sea has contributed to the increase in climate continentality (Kondratyev & Donchenko 1999). Although the drying of the Aral Sea and anthropogenically induced global warming have played roles in changing the climate, the temperature increases and changes in precipitation rates recorded over the last 40 years in Southern Priaralye are more likely a reflection of natural cyclic fluctuations in the climate (Zolotokrylin 2003).

According to estimations by the Intergovernmental Panel on Climate Change (IPCC), the mean global temperature of the atmosphere has increased by 0.3-0.6°C during the last century. This factor, together with rising trends in the concentration of CO₂ in the atmosphere, has led to conclusions that the climate, including that of Central Asia, will warm up significantly in the immediate decades resulting in further environmental changes (Chichasov & Shamen 1997, Eserkepova et al. 1996, Chub 2000).

According to predictions, the water resources in the main watersheds of Kazakhstan will reduce by at least 20-22%, droughts will increase in frequency, and the grain crop productivity will decrease by 20-23%. The scale of probable alterations in the availability of water resources in the Aral Sea Basin according to four established scenarios of climate changes is rather broad, ranging from positive values (GFDL model) to a decrease in the Syrdarya run-off by 25% and the Amudarya run-off by 40%. It is obvious that such a decrease in water resources will result in serious consequences for the countries of the region.

Contemporary and predicted changes in snow-ice and renewable water resources

In Central Asia melted snow and ice water contribute to the formation of renewable water resources. Therefore the evaluation of possible changes in water resources in the foreseeable future requires a reliable prediction of the changes in snow resources. According to analysis in Northern Tien Shan, over the last decades the average maximum

snow-water equivalent (the main component of snow resources) has not changed (Pimankina 1998, Schröder & Sevrskiy 2004). Similar results were found by Artemjeva and Tsarev (2003) for Western Tien Shan and Gissaro-Alai. In addition, the volume of river run-off has also been consistent (Schröder & Sevrskiy 2004, Chub 2000).

The situation concerning the evaluation of the dynamics of ice resources is more complicated. Investigations (Shchetinnikov 1993, 1998, Shchetinnikov & Likhacheva 1994, Dikih 2001, Dikih et al. 2001, Vilesov & Uvarov 2001, Cherkasov 2002, Cherkasov et al. 2002, Durgerov et al. 1997, Glazirin & Kodoma 2003, Severskiy & Tokmagambetov 2004) confirm that the glacial systems of Central Asian mountains develop in the same direction and have similar rates of change. Therefore, over the last few decades the area of glaciers in different regions of Tien Shan, Gissaro-Alai, Pamirs and Dzhungarskiy Alatau has decreased at the average annual rate of 0.8-1.0% (Shchetinnikov 1993, Shchetinnikov & Likhacheva 1994, Dikih 2001, Cherkasov 2002, Severskiy & Tokmagambetov 2004). These results therefore suggest that contemporary and prognostic changes in ice resources of Central Asian mountains can be assessed using the example of a single representative area that has reliable information on its glacier dynamics. In Central Asia one such area is the Balkhash Lake Basin (southeast Kazakhstan and China). The state of the glaciers of this basin was analysed for 1956, 1972 (the Dzhungarskiy Glacier System), 1975 (the Zailiyskiy-Kungeiskiy Glacier System) and 1979, and 1990 (the Northern Slope of Zailiyskiy Alatau's glacier system).

According to the results of the comparative analysis the average annual rate of decrease in the glacier area on the northern slope of the Zailiyskiy Alatau was 0.92% between 1955 and 1990 and the decrease in the net glacier volume was 1.0%. As previously mentioned, ice resources of the Ili-Balkhash Lake Basin have decreased by more than 30%. The rate of glacier retreat has not remained constant over the last few decades. An increase of nearly 50% took place between 1975 and 1979, in comparison with the previous 20 years. The rates of glacier retreat has continued to increase, however not so sharply. Similar glacier characteristics were observed for the Jazgulem River Basin on the Western Pamir (Glazirin & Kodama 2003). Moreover, this is consistent with data from recent research (Batyrov & Yakovlev 2004). Glacial retreat in four large basins of Gissaro-Alai between 1980 and 2001 is half the rate of that over the period 1957-1979. Thus, the increasing rate of glacier retreat slowed between the mid 1970s and the early 1980s.

As the level of precipitation in the mountains of Central Asia has remained constant, there is a basis to assume that the reduction in the rate of glacier retreat can be attributed to the rise in air temperature. There is further evidence from long-term observations of the perennial

permafrost in Zailiyskiy Alatau. According to this data, the temperature of the top layer of the perennial permafrost increased steadily during the 1970 and 1980s and has stabilised since the mid-1990s.

If glaciers continue to reduce in area and volume at the current rate, it can be assumed that by the middle of the 21st century the glaciers on the mountains of Central Asia will reduce by only one third and will not disappear by the end of the century as was previously expected (Cherkasov 2002, Dikih 2001, Glazirin 1996, Golodkovskaya 1982, Vilesov & Uvarov 2001). Taking into account the recurrence of the climatic cycles over the last 100 years in the region, there may be more favourable climatic conditions for glaciation in the future.

Changes in glaciation were confirmed by the results of the comparative analysis of photogrammetric surveys of the glaciers in the Small Almatinka River Basin carried out by German experts between 1958 and 1998. The thickness of ice on each glacier has been significantly reduced over most of their extent. For 40 years the thickness of the bottom layer of the Tuyuksu tang glacier, for example, has decreased by more than 45 m, and total losses of ice amounts to more than 40 million m³ (Eber et al. 2005). A reduction in the thickness of the buried parts of glaciers is also typical.

Similarly, on the majority of the area of a zone of a feed of glaciers the mass balance of ice for the specified period was close to zero (changes have made from - 5 up to 5 m). Moreover, according to a survey of 1998 in a zone of a feed of all glaciers significant sites on the area where the mass balance for the specified period appeared positive. The common increment of thickness of ice (firn) in a zone of a feed of Tuyuksu glacier has made 15-25 m. Last circumstance in a combination to stability of norms of an atmospheric precipitation gives the basis to assume probability of forthcoming change of a sign on mass balance of glaciers with negative on positive.

The fact that despite a considerable reduction in glacier resources the flow rates of the main rivers have practically not changed in recent decades suggests that there is some compensating mechanism. One explanation is that water from the melting of underground ice has accumulated as perennial permafrost. The area covered by perennial permafrost in Central Asia is many times greater than the area of present-day glaciers (Gorbunov & Severskiy 1998, Gorbunov et al. 1997). Therefore even slight melting of the permafrost could compensate for the loss of water caused by the reduction in the region's glaciers. Until now this has not been considered by the scientific community and deserves further attention given the importance of freshwater availability on the ecology and socio-economic development of the region.

There are at least two pieces of evidence that suggest such a mechanism exists. According to the results of long-term geocryological studies carried out at the Zhushalykezen Pass (Northern Tien Shan, Zailiyskiy Alatau Range) between 1973 and 1996, the temperature of frozen grounds has increased significantly. Although there have been significant inter-annual fluctuations, in Northern Tien Shan there have been general trends of rising annual ground temperatures, increased depths of thawing and decreases in the thickness of the seasonally frozen layer (Gorbunov et al. 1997). The ground depth of seasonal thawing, measured in boreholes at the Zhushalykezen Pass, increased by over 1.1 m between 1973 and 1996 (Gorbunov et al. 1997). Thus, for the specified period melt waters from a 1.1 m thick layer of recently frozen ground may have contributed freshwater to the run-off in the Aral Sea Basin.

Isotope analysis used to study the genesis of water resources also gave evidence of a compensatory mechanism. According to the results of the study, 40-50% of water, and in some cases all of the water, in the lake-dam complexes of alpine areas of Kyrgyzstan (Top-Karagai, Tuyuk-Tor, Kashka-Suu) are comprised of melt-water from buried moraine ice (Tuzova 2002).

Socio-economic impacts

Since the 1960s, climatic variations have changed the community structure of flora and fauna in the region. A reduction in the biodiversity and quality of freshwater has been caused by increasing salinity. The greater aridity of the territory surrounding the Aral Sea has reduced agro-productivity and resulted in the loss of ecosystem services. Consequently, the employment structure has changed and there are fewer investment opportunities.

There is not sufficient evidence to suggest that global climate changes are responsible for all these impacts. There is no doubt that the primary factor responsible for the acute aggravation of the ecological and socio-economic situation in the Aral Sea Basin is freshwater shortage as a result of the modification of stream flow rather than a consequence of global climate changes.

There is no proof to suggest that there is a link between global changes and the health status of the region's population. There is cause to hope that the present upward trend in average annual air temperatures may start to reduce during this century and consequently improve the environmental conditions of the region.

Conclusion and future outlook

The impacts from the concern of global changes were assessed as slight. Present-day warming reflects a cyclic trend in the climate and

the role of the anthropogenic component in this process is not believed to be as significant as often diagnosed. Hence, there is not enough evidence to rely on the predicted warming of between 2 and 6°C in the next few decades.

The conclusions differ considerably from contemporary and prognosis changes of climate and renewable water resources. Contrary to the established estimations which state that due to global warming, regional water resources will reduce by 20-40% in the near future (Chub 2000, SPECA 2004), there are grounds to argue that the volumes of river run-off will remain stable, at least over the next few decades.

Gradual air temperature increases are believed to be attributable to natural climatic changes. The glacier resources in the mountainous countries of Central Asia have reduced by more than one third during the last 30-35 years. Scientific explorations confirm that glacier resources in the Tien Shan Mountains have reduced over the past 30-40 years; by 0.92% in area and by 1% in volume annually (Severskiy & Tokmagambtov 2004). Experts predict that this process will continue for at least 100 years (Cherkasov 2002).

For the past 40 years the maximum snow storage (snow-water equivalent) volume has remained constant and the volume of river run-off has not changed significantly. The reduction in the area of glaciers has changed the inter-annual distribution of run-off, as it now contributes slightly less run-off during the vegetation period.

Despite a considerable reduction in glacier resources, the flow rates of the main rivers have remained relatively constant over the last few decades. One possibility for this could be that water inflow from underground melted ice accumulated in the perennial permafrost, which is now melting and contributing freshwater to the region's rivers. Until now this issue has not received scientific attention, but taking into account the extreme importance of probable changes in water resources as a reaction to climate changes, this aspect of the problem deserves particular consideration.

It has been forecasted that a significant diminution of water resources over the next few decades due to anthropogenic caused warming of the climate is unlikely. There are insufficient reasons to fear significant climate warming, a corresponding reduction in water resources or consequential economic losses.

Though this optimistic conclusion gives us the opportunity to predict the development of the situation in the near future, it does not make the problem less acute: water shortage in the region is one of the limiting factors of sustainable development. However, the water shortages are a result of the diversion of water for human activities rather than a reduction in the supply of freshwater resources. The transboundary nature of these regional water resources is one of the main premises for the development of international processes in Central Asia.

Priority concerns for further analysis

The GIWA concerns were prioritised in the following order:

1. Freshwater shortage
2. Pollution
3. Habitat and community modification
4. Global change
5. Unsustainable exploitation of fish

Considering the above impacts, the GIWA experts concluded that freshwater shortage was the priority issue in the Aral Sea region, as it is driving the other environmental issues facing the region. The priority issue of freshwater shortage was identified as the modification of stream flow, which by GIWA Task Team estimations accounts for approximately 70% of the development of the concern. The second most important issue for the region is pollution of existing supplies, which, it is estimated, accounts for 30% of the development of the situation in the region.

There has been an abrupt decrease in the natural run-off of the largest rivers in the region - the Amudarya and Syrdarya - which resulted in the rapid drying up of the Aral Sea. This has led to severe habitat modification including deterioration of the landscape, intensive desertification, secondary soil salinisation, an increase in the extent of climate continentality and more frequent recurrence of droughts and dust storms. The above processes caused severe degradation of both water and land ecosystems and a reduction in biodiversity. The impacts are most pronounced in the Priaralye zone.