

VLADIMIR YASINSKIY  
ALEXANDER MIRONENKOV  
TULEGEN SARSEMBEKOV

# PRIORITIES FOR COOPERATION

in transboundary  
river basins  
in Central Asia



**Eurasian Development Bank**

YASINSKIY V.A., MIRONENKOV A.P., SARSEMBEKOV T.T.

# **PRIORITIES FOR COOPERATION**

**in transboundary river basins  
in Central Asia**

УДК 556  
ББК 26.22  
У 31

Yasinskiy V.A., Mironenkov A.P., Sarsembekov T.T. Priorities for cooperation in transboundary river basins in Central Asia. – Almaty, 2012. – 232 pp.

ISBN 978-601-7151-29-4

УДК 556  
ББК 26.22

**Authors:**

Vladimir Yasinskiy,  
Alexander Mironenkov,  
Tulegen Sarsembekov

ISBN 978-601-7151-29-4

© Eurasian Development Bank, 2012

**Eurasian Development Bank**

**Address:**

220, Dostyk ave., Almaty,  
050051, Republic of Kazakhstan,  
Telephone: +7 (727) 244 40 44,  
Fax: +7 (727) 244 65 70, 291 42 63  
E-mail: editor@eabr.org  
<http://www.eabr.org>

**Coordinator:**

Gulnaz Imamniyazova, EDB

**Design, layout, and printing:**

RUAN Publishing Company

All rights reserved. No part of this publication may be reprinted or reproduced or utilised in any form or by any means, electronic or mechanical, or by any information storage and retrieval system, without permission from the authors. The views expressed in this publication are those of the authors and do not necessarily reflect the views of the Eurasian Development Bank.

YASINSKIY V.A., MIRONENKOV A.P., SARSEMBEKOV T.T.

# **PRIORITIES FOR COOPERATION**

**in transboundary river basins  
in Central Asia**

# Content

<i>List of Abbreviations</i> .....	10
<i>Foreword</i> .....	11
<i>Introduction</i> .....	13
<b>Chapter 1. Geopolitical factors in transboundary river basins and regional social, economic, water and environmental challenges in Central Asia</b> .....	<b>15</b>
1.1. Geopolitical, natural and geographical characteristics of Central Asia.....	15
1.2. Socio-economic development of Central Asia.....	19
1.3. Regional water challenges in Central Asia.....	30
<b>Chapter 2. Water resources and irrigational development in Central Asia</b> .....	<b>38</b>
2.1. Water resources management in Central Asian states.....	38
2.2. Major transboundary river basins in Central Asia.....	56
2.3. Water resources of the Aral Sea basin (based on integrated water resources management and conservation plans).....	59
2.4. Regional development of irrigation and challenges of irrigated agriculture.....	79
<b>Chapter 3. Use of water resources and water power engineering in transboundary river basins of Central Asia</b> .....	<b>95</b>
3.1. Use and management of hydropower resources.....	95
3.2. Transnational use of transboundary rivers: the Middle Syr Darya case.....	98
3.3. Shared water works and hydropower facilities in Central Asia.....	111
<b>Chapter 4. Energy security and water resources management in transboundary river basins in Central Asia</b> .....	<b>128</b>

<b>Chapter 5. Management of transboundary watercourses in Central Asia</b>	<b>140</b>
5.1. International principles of the use and conservation of water resources in transboundary river basins	140
5.2. River basin organisations	152
5.3. Integrated management and conservation of water resources of international watercourses	157
5.4. Transboundary water management: Central Asian road map	177
<b>Chapter 6. Priority areas for Central Asian cooperation in shared use of water resources of transboundary rivers</b>	<b>189</b>
6.1. Adjusting water resources management to climate change and its impact on water resources in Central Asia	189
6.2. Dam safety on transboundary rivers in Central Asia	201
6.3. Water-related disaster mitigation	215
<b>Chapter 7. Environmental and investment aspects in transboundary water resources projects</b>	<b>219</b>
7.1. Environmental responsibility of international financial institutions and the Equator Principles	219
7.2. Investment-based project design and effective practical arrangements for integrated water resources management	221
<b>Conclusion</b>	<b>224</b>
<b>References</b>	<b>226</b>

## Tables

Table 1.1	Land borders of Central Asia.....	15
Table 1.2	Brief characteristics of Central Asian states.....	16
Table 1.3	Brief geographical characteristics of Central Asian states.....	17
Table 1.4	CIS countries in international river basins.....	17
Table 1.5	Min-max range for human development indicators.....	22
Table 1.6	Human Development Index and its components in Central Asia.....	23
Table 1.7	Central Asian land resources by country and land reclamation type.....	25
Table 1.8	Deterioration of natural resources in Central Asia.....	27
Table 1.9	Key characteristics of economic development of Central Asian states.....	29
Table 1.10	Physiographic parameters of Lake Sarez.....	34
Table 2.1	Rivers and lakes in the major basins of Central Asia.....	56
Table 2.2	Surface water reserves in Central Asia.....	56-57
Table 2.3	Natural water resources of the Amu Darya Basin.....	71
Table 2.4	Natural water resources of the Syr Darya Basin.....	71
Table 2.5	Surface water resources in the Aral Sea basin.....	73
Table 2.6	Groundwater resources not affecting surface runoff.....	74
Table 2.7	Total water reserves of the Aral Sea Basin including groundwater reserves.....	75
Table 2.8	Natural water reserves, runoff and inflow in the Aral Sea basin.....	76
Table 2.9	Natural river runoff in the Aral Sea Basin.....	76
Table 2.10	Expected water demand in the Aral Sea basin by 2025.....	78
Table 2.11	Irrigation of the Ferghana Valley.....	81
Table 2.12	Estimated agricultural loss due to ineffective irrigation management.....	85
Table 2.13	Main problems and factors of land degradation in Central Asia.....	94

Table 3.1	The degree of streamflow control in the Amu Darya and Syr Darya river basins.....	97
Table 3.2	The water approach to the Shardara reservoir in 1969 according to statistics from the nearby Chinaz-Syr Darya GS and water discharge into the Arnasai.....	102
Table 3.3	Key figures of the Arnasai Lake System and Reservoir.....	104
Table 3.4	Main indicators of the Northern Aral Dam and its Spillway.....	109
Table 3.5	Planned HPP construction in Kyrgyzstan.....	119
Table 3.6	Development prospects for small HPP in Kyrgyzstan for 2010-2025.....	119
Table 3.7	Energy Performance of the planned HPP Cascade on the Charyn River.....	122
Table 4.1	Structure of CA Power Plants' Installed Capacity.....	129
Table 4.2	Central Asian Hydropower Resources.....	131
Table 4.3	Electricity Trade in Central Asian Countries, averages for 2000 – 2008.....	136
Table 4.4	Results of the SWOT Analysis for the United Energy System.....	137
Table 5.1	International River Basins with River Basin Organisations.....	153
Table 5.2	International River Basin Organisations.....	154
Table 5.3	Gauging Stations in Central Asia.....	158
Table 5.4	Participation of Central Asian Countries in Various International Agreements on Transboundary Water Resources.....	185
Table 5.5	Some global programmes and reports on water resources.....	187
Table 5.6	Organisations publishing water statistics resources at the global level.....	188
Table 6.1	Summary of main indicators of large hydraulic projects in Central Asia.....	203

## Figures

Figure 1.1	Map of Central Asia.....	16
Figure 1.2	Mountain ecosystems in Central Asia.....	18
Figure 1.3	Population size of Central Asian nations.....	20
Figure 1.4	Natural population increase in Central Asia.....	20
Figure 1.5	Flow of migration in CAC during 2000-2005.....	21
Figure 1.6	Central Asian population estimates.....	22
Figure 1.7	Grain production in Central Asia.....	26
Figure 1.8	Grain production per capita in Central Asia.....	26
Figure 1.9	Breakdown of Central Asian GDPs by sectors of economy.....	28
Figure 1.10	The Caspian sea.....	31
Figure 1.11	Lake Balkhash.....	32
Figure 1.12	Issyk-Kul Lake.....	33
Figure 1.13	Water level in Lake Sarez, Central Pamirs.....	36
Figure 1.14	Hotspots of hazardous industrial waste in the Ferghana Valley.....	37
Figure 2.1	Map of Kazakhstan.....	39
Figure 2.2	Kazakhstan river basins.....	40
Figure 2.3	Map of Kyrgyzstan.....	43
Figure 2.4	Tajikistan river basins.....	46
Figure 2.5	Map of Turkmenistan.....	50
Figure 2.6	Map of Uzbekistan.....	52
Figure 2.7	Water diverted from natural water sources in Central Asia.....	57
Figure 2.8	Water use in Central Asia.....	58
Figure 2.9	Transboundary surface water in Central Asia.....	58
Figure 2.10	Water resources of the Aral Sea basin.....	64
Figure 2.11	The Syr Darya River Basin.....	65
Figure 2.12	The Amu Darya River Basin.....	68
Figure 2.13	Water withdrawal and availability in the Aral Sea basin.....	72
Figure 2.14	Irrigated land in the Aral Sea basin.....	79
Figure 2.15	Irrigated land in Uzbekistan.....	80

Figure 2.16	Qarshi irrigation system.....	82
Figure 2.17	Annual average energy surplus in hydropower stations in Kyrgyzstan and Tajikistan.....	83
Figure 3.1	Headworks of the Koksaray Counter Regulator.....	103
Figure 4.1	Dynamics of Electricity Production in Central Asian Countries.....	133
Figure 4.2	Natural Gas Production.....	133
Figure 4.5	Oil Drilling, including Gas Condensate.....	133
Figure 4.4	Coal Mining.....	134
Figure 5.1	The Components of a Basic Water Resources Assessment Programme.....	159
Figure 5.2	Suggested Content of a Master Plan for the Integrated Management and Conservation of Water Resources.....	161
Figure 5.3	Suggested Content of a Basin Plan for the Integrated Management and Conservation of Water Resources.....	165
Figure 6.1	Economic costs of natural disasters.....	190
Figure 6.2	River runoff in average water year and contribution of glacier melt.....	194
Figure 6.3	Change in the glacier volume in Tajikistan.....	195

# List of Abbreviations

AALS – Aidar-Annasai Lake System  
BWA – basin water association  
CA – Central Asia  
CAC – Central Asia and the Caucasus  
CIS – Commonwealth of Independent States  
EurAsEC – Eurasian Economic Community  
GDP – gross domestic product  
GLAAS – Global Annual Assessment of Sanitation and Drinking-Water  
GS – gauging station  
HDI – human development index  
HPP – hydropower plant  
ICOLD – International Commission on Large Dams  
ICWC – Interstate Commission for Water Coordination in Central Asia  
IWRM – Integrated water resources management  
MW – megawatt  
NATO – North Atlantic Treaty Organisation  
OSCE – Organisation for Security and Cooperation in Europe  
PPP – purchasing power parity  
SPECA – Special Program for Economies of Central Asia  
TPP – thermal power plant  
UES – Unified Energy System  
UN – United Nations  
UNDP – United Nations Development Programme  
UNECE – United Nations Economic Commission for Europe  
UNEP – United Nations Environment Programme  
UNESCAP – United Nations Economic and Social Commission for Asia and the Pacific  
UPS CA – Unified Power System of Central Asia  
USSR – Union of Soviet Socialist Republics  
WHO – World Health Organisation  
WW – waterworks  
WWAP – World Water Assessment Program  
WWDR – World Water Development Reports

# Foreword

Water resources are used more extensively and faster than any other resources, having a significant impact on the natural processes shaping both the geographical environment and the international relations in transboundary river basins. This is a particularly sensitive issue in Central Asia, which has limited water resources.

As a financial instrument promoting integration in the post-soviet countries, the Eurasian Development Bank sees integrated water resources management as an important area for investment. This study authored by Yasinskiy V.A., Mironenkov A.P. and Sarsembekov T.T. considers water sector issues in the development context of Central Asia.

The growing water deficit in transboundary river basins of Central Asia determines the need to develop water facilities, promote water saving and ensure sound water management in all sectors of the economy, which requires significant long-term investment. To achieve sustainable development of river basins, any solution tried out in one part of a basin should take into account the potential environmental impact and effects on water conditions in the remaining part of the basin.

Of serious concern are natural disasters such as earthquakes, flooding, landslides, and mud flows, all of which threaten the safety of dams and water reservoirs, human settlements and urban areas along the rivers of Central Asia. Another concern shared by all Central Asian states is the shrinking Aral Sea, which is a major ground zero of natural and environmental crises. The International Fund for Saving the Aral Sea exists to address these issues. This study will contribute to the improvement of the social and environmental situation in the region.

The authors note that water management in transboundary river basins is a shared concern, which enables the development of unified approaches to shared water resources management. At the same time, differences in natural, climatic, economic and political conditions of each country cause major disagreements in interstate water relations. The legal regulation of water relations between Central Asian states would enable investment in the water sector and other sectors of the regional economy and promote more active involvement of international financial institutions.

Sound feasibility studies of the present and future of water resources management completed at the stage of project design will reduce risks of investment projects related to water resources use in different sectors

of the economy. Long-term investment in water facilities and hydropower development can only be made with engagement of highly qualified human resources. The authors rightfully note that the human resources aspect of investment and innovation policies is still somewhat neglected in Central Asia. The impact of the lack of qualified staff is felt at all stages starting from project design to construction and operation of water facilities and hydropower infrastructure.

This monograph makes a significant contribution to the search of solutions to water supply and hydropower problems in Central Asia, and the approaches offered by the authors may be of great practical interest to researchers, experts and graduate students involved in investment planning and water resources management.

**Professor Sagit Ibatullin**

Chairman of the Executive Committee  
International Fund for Saving the Aral Sea

# Introduction

The geopolitical unit of Central Asia consisting of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan emerged after the collapse of the Soviet Union in 1991. Although research and reference literature may still refer to the region as Central Asia and Kazakhstan to identify its geographical position, the region's modern name has been commonly used to mark its role in the global politics and economy. Central Asia covers a vast endorheic territory within the closed Aral-Caspian basin, which determines a particular river regime sensitive to human activity and climate change.

The region's environment and geography account for a particular pattern of streamflow generation in river basins, while its political and economic conditions specify streamflow use patterns. All Central Asian states share the understanding that regional cooperation is instrumental in managing transnational waters, protecting river basins from pollution and preventing exhaustion of water resources, all of which contribute to sustainable water management and economic prosperity of each individual country. The position of the region and the fact that it is made up of landlocked countries dictates the need for enhanced trade and economic ties and stronger integration.

All major Central Asian rivers are transboundary rivers, while river flow, which accounts for the bulk of usable water, includes flow formed domestically and from the neighbouring countries. Therefore, in order to juggle the clashing needs for water supply, power generation, irrigation and environmental needs in transboundary river basins, a coordinated approach is needed to manage water bodies and water resources at the regional and national levels. The changing climate and water resources of Central Asia such as increasingly recurrent and long-lasting dry and high-water periods factor contribute into increasing water-related disasters such as flooding, land sliding, mud flows, drought, etc. The changing regime of rivers and resulting changes in water use patterns stir up regional competition for water resources. In this context, an integrated approach to land and water management, development of water facilities and adequate investment comes to the forefront.

Each river basin has its own characteristics and conditions for water use and water resources management. However, all countries of the region practice similar watershed management styles based on the integrity of river ecosystems and multicomponent natural environment. River basins are viewed as integrated geographical areas with unique social, economic and environmental contexts, to which water management schemes should

be adjusted. As a result, Central Asian laws pertaining to water bodies and water resources management link water use with environmental factors and economic aspirations with the environmental safety of river basins. Watershed management principles are becoming important to the cooperation between Central Asian states in transboundary river basins and gradually bringing together the individual interests of each state in each river basin through internationally accepted legal provisions pertaining to the shared management of transboundary streams.

In order to promote sustainable transnational water management, the changing regimes of transboundary rivers should be accommodated. This requires improved access to hydrological and hydro meteorological information and improved exchange of this information between the countries. In this context, building national capacity in responding to climatic and hydrological changes should be a priority of regional cooperation.

Central Asian states share water management concerns in transboundary river basins. This allows the development of a common approach to joint management of water and energy resources. A growing water deficit in transboundary river basins determines the need to develop water facilities, promote water saving and ensure sound water management in all sectors of the economy, which requires significant long-term investment. The role of international financial institutions becomes increasingly important for such an important area of international relations.

Given the growing investment needs to develop the water management infrastructure in Central Asia in the context of growing shortage of water in transboundary river basins, political and legal measures should be taken to regulate water relations that respect the interests of all parties and ensure an environmentally friendly regime for the rivers in question.

# Geopolitical factors in transboundary river basins and regional social, economic, water and environmental challenges in Central Asia

## 1.1. Geopolitical, natural and geographical characteristics of Central Asia

Located in the heart of Eurasia, Central Asia is the seventh largest region in the world with a total area of 4 million km<sup>2</sup>. It borders with Russia to the north-west, Iran and Afghanistan to the south and Russia and China to the east. All Central Asian states are landlocked.

State	Borders with	Length of border (km)
Kazakhstan	China, Kyrgyzstan, Russia, Turkmenistan, Uzbekistan	13,394
Kyrgyzstan	China, Kazakhstan, Tajikistan, Uzbekistan	3,878
Tajikistan	Afghanistan, China, Kyrgyzstan, Uzbekistan	3,651
Turkmenistan	Kazakhstan, Uzbekistan, Iran, Afghanistan	3,736
Uzbekistan	Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Afghanistan	6,221

**Table 1.1**  
Land borders  
of Central Asia

Source: RK, 2011;  
Atlas, 2011

Central Asia is a vast endorheic area within the closed Aral-Caspian basin covering the subtropical zone as well as the southern edges of the temperate zone. The region's geographical position in the inland desert zone, remoteness from the seas and the ocean as well as its orographic structure determines continental climate and resulting hydrographic network and river regimes. Central Asia is orographically divided into two parts: western part taking up 70% of its territory with predominant lowlands (Turan Plain) and eastern part with its mountain ranges, which is where the region's water resources are formed. The north-western part of the region is home to the eastern part of Caspian Depression. Adjacent



**Figure 1.1**  
Map of Central Asia

Source: ADB, 2010: 24-25

	Area (thousand km <sup>2</sup> )		Resident population (million people, as at year end)		Population density (people per 1 km <sup>2</sup> )	Share of lands of multiple use out of total area (%)			
	total	% of CA	total	% of CA		a	b	c	d
Kazakhstan	2,724.9	67.99	16.4	25.47	6	33.7	8.6	1.5	56.2
Kyrgyzstan	199.9	4.99	5.5	8.54	27	28.6	13.4	3.8	54.2
Tajikistan	143.1	3.57	7.6	11.8	53	50.5	26.5	0.3	22.7
Turkmenistan	491.2	12.25	6.7	10.4	14	69	25	–	6
Uzbekistan	448.9	11.2	28.2	43.79	63	59.5	3.1	1.8	35.6
Central Asia	4,008	100	64.4	100					

**Table 1.2**  
Brief characteristics of Central Asian states (2010)

Source: CIS ISC, 2011a

Note: a – land for agricultural use;  
b – land for forestry use;  
c – land for water bodies use;  
d – other

	Highest point (m)	Largest lakes (thousand km <sup>2</sup> )	Longest rivers stretching along state territory (km)	Multiyear average temperature	
				January	July
Kazakhstan	Khan-Tengri Peak (Saryzhaz range) – 6,995	Caspian Sea – 0.4*, Aral Sea – 46.6**, Balkhash – 18.2**	Irtys – 1,700, Esil – 1,400, Syr Darya – 1,732, Zhayik – 1,082	min –3°C max –18°C	min +19°C max +29°C
Kyrgyzstan	Pobeda Peak – 7,439	Issyk-Kul – 6.2**, Sonkul – 0.3*, Chatyr-Kul – 0.2**	Naryn (total length) – 578, Chu – 381, Talas – 194, Chatkal – 175	min –2.2°C max –29.1°C	min +4.1°C max +26.8°C
Tajikistan	Somoni Peak – 7,495	Karakul – 380, Sarez – 86.5, Zor-Kul – 38.9	Zeravshan – 781, Bartang-Murgab-Oksu – 558, Vakhsh – 524	+1.9°C	+26.7°C
Turkmenistan	Aira Baba Mountain – 3,139	Caspian Sea – 0.4*	Amu Darya (total length) – 1,415, Tejen (total length) – 1,150	min –7°C max +6°C	min +28°C max +31°C
Uzbekistan	Hissar Mountains – 4,643	Aral Sea – 46.6**	Syr Darya (total length) – 2,212, Amu Darya (total length) – 1,415, Zeravshan (total length) – 877	min –8°C max +4°C	min +22°C max +32°C

to the Aral Sea are the present-day and ancient deltas of the Syr Darya and the Amu Darya. The region's largest rivers are transboundary rivers crossing two or more Central Asian and neighbouring states.

Isolated river basins determine a particular pattern of river basin formation and related water use as well as necessitate sustainable water management and protection from pollution and exhaustion.

**Table 1.3**  
Brief geographical characteristics of Central Asian states

Source: CIS ISC

Note: \* million km<sup>2</sup> (total area);  
\*\* thousand km<sup>2</sup>

Country	International basins	Total area of country within international basins (km <sup>2</sup> )	Percentage of country within international basin
Kazakhstan	Aral Sea, Ili/Kyunes Khe, Ob, Ural, Pu-Lun-To, Tarim, Volga	1,739,057	64.03
Kyrgyzstan	Aral Sea, Ili/Kyunes Khe, Tarim	170,614	85.59
Tajikistan	Aral Sea, Tarim	14,024	9.85
Turkmenistan	Aral Sea, Atrak, Ghari/Gherirud, Murghab	52,956	11.23
Uzbekistan	Aral Sea	236,695	53.11

**Table 1.4**  
CIS countries in international river basins (%)

Source:  
www.cawater-info.net/twinbasin;  
www.twinbasin.org

Relatively cold winters and hot and long summers are typical for Central Asia, in particular, its flatlands. Temperature patterns vary from zone to zone. Temperature distribution in mountainous areas depends on land height and forms as well as direction of slopes. A significant share of flatlands with different landscapes lies, on average, 100-300 m above the sea level. Sea level altitudes go down to 63 m in areas adjacent to the Aral Sea. Flatlands and river valleys, sometimes shaped as long strips, fold into mountain ranges. The highest Central Asian mountains are usually spread out and stretch to the west and south-west. This, to a significant extent, permits a humid airflow and enables considerable precipitation and accumulation of water in mountainous areas. It explains the formation of large glacial areas in eastern parts of the region including the Fedchenko Glacier in the Pamir Mountains, and the Inylchek Glacier in the Tien Shan mountains, as well as transboundary rivers of the Amu Darya and the Syr Sarya, the Zeravshan, the Shu, the Talas and the Irtysh.



**Figure 1.2**  
Mountain  
ecosystems  
in Central Asia

Source:  
Zoï Environment  
Network, 2011: 38

The climate and weather conditions of mountainous areas have a direct impact on the multiyear river regimes and water resources management. Central Asia is known for a high number of degree-days during the crop season. Thus, in southern Uzbekistan and Tajikistan accumulated temperature over the period with stationary temperature of  $+10^{\circ}\text{C}$  reaches

4,800-5,400°C in Qarshi steppes, 4,600-5,000°C in the lower reaches of the Zeravshan and central Kyzyl Kum and 3,600-4,200°C in the lower Amu Darya and the Ustyurt Plateau (Lutz, 2010: 41).

Atmospheric humidity is an important factor, especially in dry areas. The annual variation of relative air humidity in Central Asian flatlands is typical of a continental climate and is a mirror image of the annual variation of atmospheric temperatures reaching its maximum in winter months and minimum in summer months with a great annual range. Dry days are those with the relative air humidity index falling to 30% or below over an observation period and are important to agricultural planning. High temperatures and a deficit in air humidity cause great water evaporation. Central Asia is considered to have high water evaporation potential both annually and monthly. Shortage of precipitation is particularly felt during the crop season when rains are scarce between June and September. In the Central Asian climate, flora, dominating soil and other natural factors change consistently from zone to zone. A great variety of natural conditions determine the varying depth and duration of the snow cover. The snow and glaciers in the Central Asian mountains accumulate water and have a significant impact on the formation of the region's river flows and regimes.

## **1.2. Socio-economic development of Central Asia**

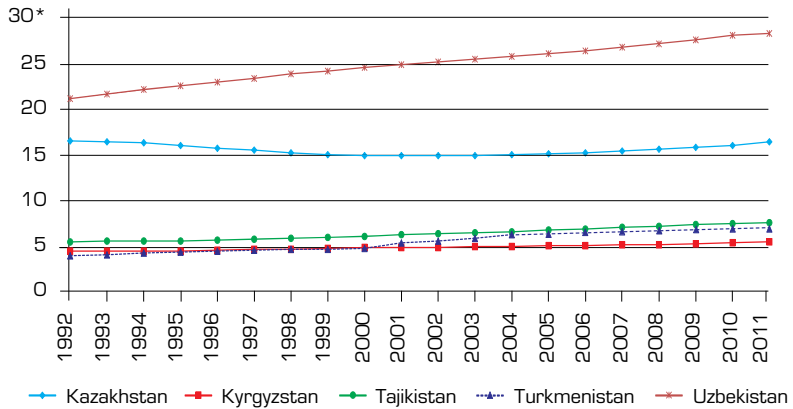
Demographic factors have a decisive impact on economic development and water management in Central Asia. In the context of geographical isolation and, consequently, closed transboundary river basins, demographic processes are a key factor determining transnational water management and interstate relations both in the present and in the future. As at the start of 2011, the aggregated population of Central Asia was 64.42 million people, which are 46.9 million people more than in 1950. This suggests that on average the population of the region increased by 7.8 million people in each decade of the period under review.

Statistical data for 2011 suggests that 28.2 and 16 million people live in Uzbekistan and Kazakhstan respectively. Tajikistan, Kyrgyzstan and Turkmenistan are categorised as small nations with populations between 5 and 7 million people. The Ferghana Valley lying in parts of Uzbekistan, Tajikistan and Kyrgyzstan is home to over 20% of the total population of Central Asia and is considered its most populated area. Population density in certain parts of the Ferghana Valley reaches 200-500 people per km<sup>2</sup>. High population density in the valley is viewed as a key factor boosting competition for water both at the local and interstate level. As a transit section of the Syr Darya with Kazakhstan in the downstream, the Ferghana Valley stands out in international transboundary river management practice as the most challenging area for transnational water apportioning.

**Figure 1.3**  
Population size of Central Asian nations

Source: CIS ISC

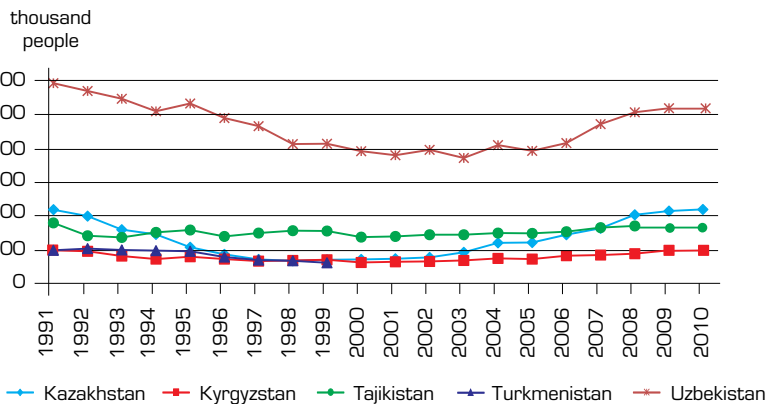
Note: \* million people (as per year start)



Overall, Central Asian nations are similar in terms of the age composition of their population, which is largely determined by distinctive demographic behaviours.

**Figure 1.4**  
Natural population increase in Central Asia

Source: CIS ISC



Consistently high birth and population increase rates over a long period of time have contributed to the young age composition of the Central Asian population with nearly double the levels of children and adolescents compared to such CIS countries as Belarus, Russia and Ukraine.

Domestic and international migration of the working age population caused by socio-economic factors has significantly impacted the size and composition of the population of Kyrgyzstan, Tajikistan and Uzbekistan. Most migrants leave these countries for Russia and Kazakhstan.

The majority (as much as 57.5%) of people of Kazakhstan reside in urban areas and urban-type villages, whereas rural population prevails in Kyrgyzstan, Tajikistan and Uzbekistan accounting for 64.1%, 72.8% and



**Figure 1.5**  
Flow of migration  
in CAC during  
2000-2005

Source: CAC DRMI,  
2010: 91

63.3% of the population respectively. Women account for 49.4% of the labour force in Kazakhstan, 42.75% in Kyrgyzstan, 45.2% in Tajikistan, 39.3% in Turkmenistan and 39.8% in Uzbekistan. The highest percentage of women employed in agriculture is in Tajikistan and Turkmenistan (53.2%). In Uzbekistan and Kyrgyzstan, 43.5% and 29.8% of those employed in agriculture are women. In Kazakhstan, the percentage of women employed in agriculture is the lowest (24.2%) (CIS Interstate Statistical Committee).

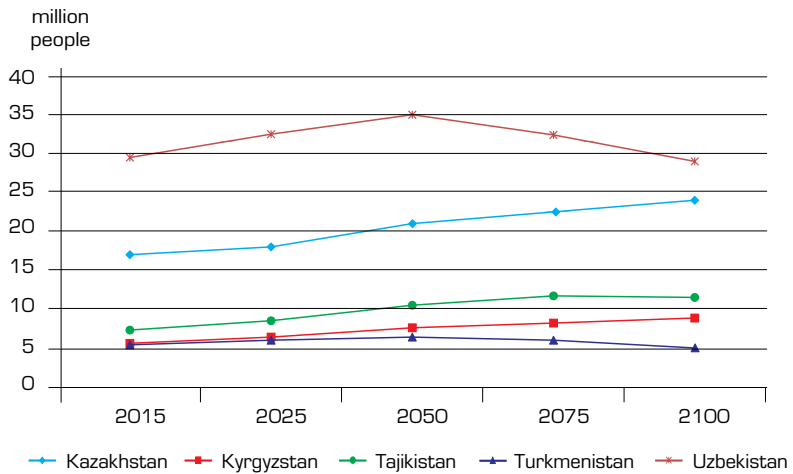
Central Asian urbanisation is relatively stable. At the same time, it is forecasted to increase in the coming decades. Urbanisation is a complex issue for the region as migration coupled with shrinking rural population and fast growing urban population may become a critical factor for the sustainable operation of social infrastructure, including water supply facilities. Migration from rural areas may lead to a shortage of qualified agricultural specialists in the future. A dramatic increase in urban population will require, first of all, more social infrastructure and new jobs.

The expected demographic trends in Central Asia are, in many respects, linked to the indicated age composition of the population resulting from a high birth rate in the past and a significant birth rate in the present. Therefore, the future population growth is, to a large extent, predetermined by the current make up of the population characterised by a prevailing percentage of young people: youth under 15 account for one third of the population. A number of

alternative birth trends indicate an extensive range of uncertainty, which is reflected in the population growth scenarios. These scenarios suggest the region’s population to potentially range from 65 million to 133 million people by 2100 (UN DESA, 2011).

All estimates demonstrate the following median value of population growth for Central Asia: from 60.7 million people now to 80.5 million in 2050 and from 80.8 million in 2075 to 78.35 million in 2100 (see Table 1.6). Thus, in the coming decades the population of Central Asia will grow with high population growth rates then decelerating and even falling as of 2050.

**Figure 1.6**  
Central Asian population estimates (second scenario)  
Source: UN DESA, 2011



How well the region’s economy can be adjusted to the demographic processes depends on how much more will be invested in the social infrastructure development, and, primarily, the water sector. All of this will indicate the level of a country’s socio-economic development, which is internationally measured by the so-called Human Development Index (HDI). A country’s HDI ranking shows how far or close it is to achieve life expectancy of 85 years, equal access to education and decent income for all people.

According to the UNDP methodology, the HDI aggregates such indicators as longevity, knowledge and standard of living within their min-max range listed in Table 1.5.

**Table 1.5**  
Min-max range for human development indicators  
Source: UNDP, 2011

Indicator	Min	Max
Life expectancy at birth (years)	25	85
Literacy rate (%)	0	100
Enrolment rate (%)	0	100
GDP per capita (\$ at PPP)	100	4,0000

*Gross Domestic Product (GDP) per capita*, which is an indirect basic indicator, is used to measure the material well-being of the population. To ensure international comparability, it must be converted into real GDP per capita (in US dollars) in purchasing power parity (PPP) of the national currency with regard to the US dollar.

In order to compare the socio-economic development of the world's countries as measured by HDI, since 1990 UNDP has produced annual human development reports that give global HDI rankings for all countries and detail other indicators reflecting the countries' social achievement. Countries are grouped according to their HDI ranking into countries with very high, high, medium and low human development level. Thus, Human Development Report 2011 "Sustainability and Equity: A Better Future for All" ranks 187 countries and territories with Norway (0.943), Australia (0.929), and the Netherlands (0.910) ranked highest, and Burundi (0.316), Nigeria (0.295), and Democratic Republic of Congo (0.286) ranked lowest (HDI values are indicated in the brackets). Due to high social development indicators, such as health, education, and life expectancy, achieved during the soviet period, all Central Asian countries have relatively good HDI rankings. In the global ranking, Kazakhstan falls into the category of countries with high human development, while other Central Asian states fall into the category of countries with medium human development.

Country	HDI ranking	HDI (value)	Life expectancy at birth (years)	Average duration of schooling (years)	Expected duration of schooling (years)	Gross national income (GNI) per capita (\$ at PPP in 2005 value)
		2011	2011	2011	2011	2011
Kazakhstan	68	0.745	67	10.4	15.1	10 585
Turkmenistan	102	0.686	65	9.9	12.5	7 306
Uzbekistan	115	0.641	68.3	10	11.4	2 967
Kyrgyzstan	126	0.615	67.7	9.3	12.5	2 036
Tajikistan	127	0.607	67.5	9.8	11.4	1 937

**Table 1.6**  
Human Development Index and its components in Central Asia

Source: UNDP, 2011

Over 2000 and 2010 the aggregate GDP of Central Asia grew five-fold from \$39.39 billion to \$201.51 billion, while GDP per capita growth ratio varies from country to country (CIS Interstate Statistical Committee).

The land resources of five Central Asian states, which are Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan, total over 351.7 million ha, of which agricultural lands account for 294.2 million ha. 74.8%

of these or 220.1 million ha are rangeland and hay fields. Plough lands account for 39.975 million ha, of which irrigated plough lands cover 10.219 million ha. 77.3% of all plough lands are in Kazakhstan, of which only 7% are irrigated with the remaining lands being non-irrigated or highly dependent on precipitation. 42.4% or 10.219 million ha of Central Asian irrigated lands are in Uzbekistan, 22.7% in southern Kazakhstan (located in the Syr Darya basin, which is a transboundary river), 17.2% in Turkmenistan, 10.6% in Kyrgyzstan, and 7.1% in Tajikistan. Likewise, rangelands are distributed unevenly across Central Asian states. 50% of all Central Asian rangelands are in Kazakhstan, 25.3% in Kyrgyzstan, 9.9% in Tajikistan, 8.14% in Turkmenistan, and 6.4% in Uzbekistan. The category of land resources determines which branch of agriculture is more developed in the countries of the region. Thus, Kazakhstan is more focused on grain-growing (dry land), cattle breeding, and, partially, irrigated farming, while Kyrgyzstan focuses on cattle breeding and crop growing, and Uzbekistan, Turkmenistan and Tajikistan on irrigated farming and, to a lesser extent, cattle breeding (ICARDA, 2009: 66).

All land resources of Central Asia potentially usable for agricultural development can be classified as follows according to the natural conditions and reclamation needs:

- Type I land in no need of artificial drainage;
- Type II land in need of minor engineering reclamation;
- Type III land in need of extensive reclamative engineering up to the standard used for large irrigation projects;
- Type IV land in need of extensive complex reclamation that makes irrigation of such land unpractical;
- Type V land partially suitable for reclamation. Sets of soils or relatively limited combinations of soil contours within lands of types I–IV aggregately recommended for agricultural reclamation;
- Type VI floodplain land. Naturally irrigated forage lands need to be drained and dammed before they can be used for tillage;
- Type VII land not recommended for reclamation: areas of largely broken relief in need of extensive engineering works for any type of irrigation (Volynov et al., 1980).

In Central Asia, of 87.3 million ha of land is potentially suitable for irrigation, excluding type VII lands, type I, II and III lands occupy 35.7 million ha, which need several times the irrigation capacity of the rivers and ground waters of the entire region. 16.5 million ha are type IV lands, which cannot be developed without holistic reclamation engineering. 33.2 million ha are type V lands – to all intents and purposes the development of large areas of such land is not

recommended. Floodplain lands of type VI make up a relatively small area of 1.9 million ha.

Country	Irrigable land	Land reclamation types					
		I	II	III	IV	V	VI
Uzbekistan	12,351	1,400	2,039	5,439	3,347	126	–
Tajikistan	1,009	490	203	269	46	1	–
Turkmenistan	12,865	1,500	2,031	4,963	3,953	418	–
Kyrgyzstan	1,601	802	440	28	331	–	–
Kazakhstan	54,490	1,100	4,310	10,630	8,820	32,690	1,940
Total	87,316	5,292	9,023	21,329	16,497	33,235	1,940

The classification and distribution of Central Asian lands into reclamation types is of practical relevance primarily in order to study the technical, economic and environmental feasibility of the development of new areas. The data listed above indicates that type I lands are already being utilised for irrigated agriculture. Out of the 30.35 million ha under type II and III lands, 4.93 million ha are used for irrigated farming. However, expanding type II and III lands for irrigation is difficult due to the exhausted irrigation capacity of the rivers and the need for complex reclamation works requiring considerable investment. It should be noted that the depreciation rate for the existing irrigation infrastructure is 70-80% of its physical capacity, and there is an urgent need for its renovation and upgrade. The aggregate cost of renovations match the cost of new irrigation projects, which justifies the cost-effectiveness of channeling financial and material resources to renovate the existing irrigation infrastructure. This will increase the effectiveness of irrigated agriculture and enable a shift to water and energy saving methods of cropping.

**Table 1.7**  
Central Asian land resources by country and land reclamation type (thousand ha)

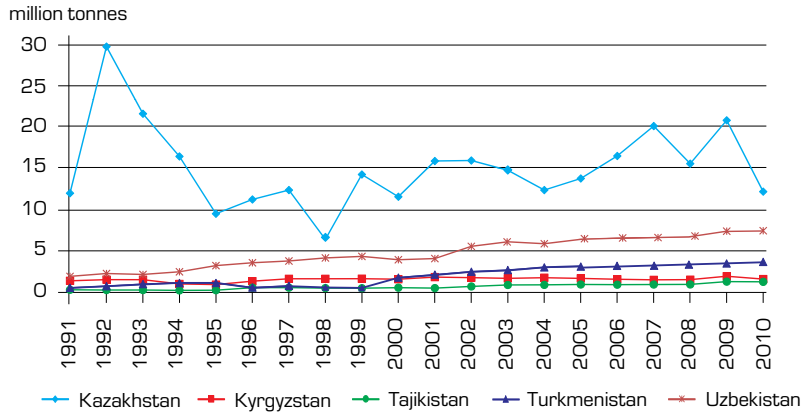
Source: Volynov et al., 1980: 14

Agriculture plays a key role in ensuring the food security and sustainable economic development of Central Asia. Changing ownerships patterns have lead to a changed composition of agricultural producers and an expansion of the private sector. In 2010 household and commercial farming accounted for 81-98% of all agricultural produce produced in Kazakhstan, Kyrgyzstan and Tajikistan.

Effective land and water resources management and joint programmes and projects on irrigated land reclamation are important items for the intergovernmental cooperation agenda on ensuring water, food, energy and environmental security in Central Asia. All CA nations have adopted and consistently implemented national food security programmes, including grain independence. The agricultural policies of CA states focus on achieving self-sufficiency in agricultural produce. New underproductive lands are developed for cropping and irrigated lands expanded against a backdrop of limited, and even deficit, water resources. Food security programmes underuse the

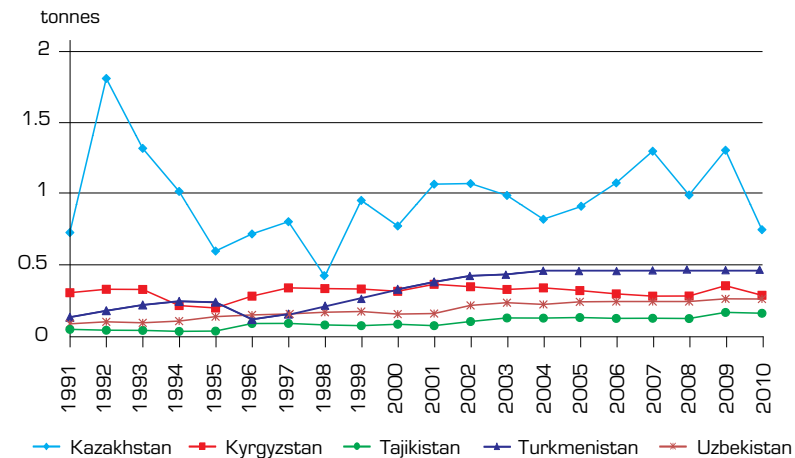
**Figure 1.7**  
Grain production in Central Asia

Source: CIS ISC



**Figure 1.8**  
Grain production per capita in Central Asia

Source: CIS ISC



potential of agricultural specialisation and food trading. These policies may prove unsustainable as they undermine the effective use of land and water resources according to natural and climatic characteristics. For example, if Kazakhstan were to specialise in high-quality grain production it could meet the grain supply needs of other Central Asian states. This would in turn free up large areas of land currently used for grain cropping and reduce intake of water for irrigation of grain crop areas in other countries. Based on good natural and climatic conditions other Central Asian countries could specialise in growing and the processing of more lucrative crops such as fruits and vegetables. Underutilisation of agricultural specialisation adds to the inputs and costs and undermines the quality of agricultural produce while also reducing the competitiveness of Central Asian states' agricultural produce both on international and national markets (ICARDA, 2009: 66). These agricultural policies are a contributing factor to the growing water deficit and competition for water.

The percentage of land used for agriculture continues to decrease because land is transferred for non-agricultural use, water and wind erosion increases, the degree of salinity and bogging of irrigated land grows and arable land becomes unsuitable for agriculture due to drying and desertification of rangeland. Land fertility and the quality score continue to fall, while the quality of irrigation water continues to decline. Forage, companion and interplant cropping are not rotated on irrigated areas, while food programmes fail to incorporate measure to conserve land fertility.

Low yield of agricultural crops, ineffective price regulation on markets of agricultural produce and inadequate government subsidies for agriculture mean that private farming is not very profitable. Large farms operating in irrigated agricultural areas have been discontinued and used as a basis for smaller land users. This resulted in the fragmentation of irrigation systems into smaller systems, which in turn hampers the distribution and conservation of irrigation water. Denationalisation of irrigation management services, a lack of funds for reclamation and the deterioration of agricultural infrastructure have also contributed to the deterioration of irrigation systems and the declining reclamative quality of land. Private farmers also do not have the resources for land fertility conservation measures.

Country	Deteriorate of natural resources and biodiversity			Population living on degraded land (%)	People affected by disasters (annual average per 1 million people)
	Deterioration of natural resources (% of GNI)	Forested land (% of land)	Endangered species (% of all species)		
Kazakhstan	22	1.2	8	23.5	442
Turkmenistan	0.5	4.8	6	11.1	
Uzbekistan	0.2	2.9	6	27	5
Kyrgyzstan	30.4	8.8	8	9.7	37,899
Tajikistan	17.8	7.7	7	10.5	47,642

The impact of global climate changes on the formation and melting of glaciers and, consequently, on the hydrological regime of the rivers becomes particularly noticeable in the condition of the region’s irrigated farming. Agriculture depends on climatic and environmental conditions more than other sectors of the economy. Climate, hydrological regime of rivers, relief, soils and reclamation needs determine the location of irrigated lands and agricultural specialisation.

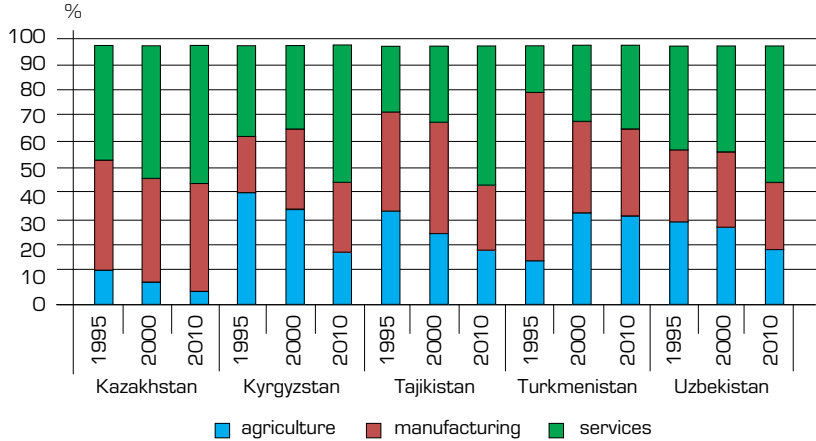
The productive forces of Kazakhstan and Turkmenistan have an industrial-agrarian structure, while in Uzbekistan, Tajikistan and Kyrgyzstan the structure is rather agriculture oriented. The macrostructure of the Central Asian economy has significantly changed with national economies adjusting primarily to demand and resource potential. It is principally important to note

**Table 1.8**  
Deterioration of natural resources in Central Asia

Source: CAC DRMI, 2010

that structural changes of the post-soviet economies reflect the adjustment of the inherited economies to a conceptually new environment, rather than the processes of contemporary economic growth.

**Figure 1.9**  
Breakdown of Central Asian GDPs (%) by sectors of economy  
*Source: UNCTAD, 2011; CIS ISC*



The share of GDP accounting for services has risen across Central Asian states. Likewise, manufacturing output became an aggregated indicator of sectoral outputs with larger shares attributed to metallurgy, fuel production and electric power industries. In almost all CA countries the ratio is dominated by fuel and energy resources and mining and metallurgical production, which indicates a disproportion between the development of the mining sector and manufacturing in other sectors with high value added. The relative contribution of the agricultural sectors varies across countries; overall, however, the share of agriculture and other sectors has declined compared to that of the mining sector.

Central Asia's transition to the market economy was followed by a remarkable reduction in manufacturing output in the first four years. The economic decline of the 1990s turned into sustained growth that followed from 1998 until 2008 when it was interrupted by the global financial crisis that hampered the development of Central Asian states (Zhukov, Reznikova, 2001: 488).

Table 1.9 presents information that allows comparison of economic development across Central Asian states. It offers a summary of structural characteristics of the manufacturing output, employment and foreign trade with a very general assessment of the prevailing economic system. Kazakhstan, Kyrgyzstan and Tajikistan have market economies and have undertaken a reform of the water resources and supply management sector. Differing patterns of economic development and, as a result, water sector management, require a more flexible mechanism for interstate cooperation, primarily in the management of the water and energy resources

of transboundary rivers. The countries have taken up the role of exporters of mineral and/or agricultural resources and metals in the global division of labour. In all countries, except for Kazakhstan, agriculture accounts for a growing aggregate employment ratio. In Kazakhstan and Kyrgyzstan where a market economy prevails, the overall structure of production reflects the countries' economic specialisations. The composition of output for Turkmenistan and Uzbekistan is less explicit due to their particular domestic price systems. Agriculture and services are most developed in Uzbekistan, Kyrgyzstan and Tajikistan; services and industrial sectors in Kazakhstan; and industrial sectors and agriculture in Turkmenistan. Oil plays an increasing role in Kazakhstan's economy, while Uzbekistan and Turkmenistan still rely on the export of natural gas.

	Specialisation in global economy	Leading sectors	Sectors with highest employment rate	Type of economy
Kazakhstan	Export of mineral resources and metals	Services, extractive industry	Labour surplus in informal sector in urban areas	Market
Kyrgyzstan	Export of electric energy and gold	Agriculture	Labour surplus in agriculture	Market
Tajikistan	Export of aluminum and raw cotton	Services, manufacturing and construction	Labour surplus in agriculture	Market
Turkmenistan	Export of mineral resources and raw cotton	Manufacturing, construction and services	Labour surplus in agriculture	Similar to the Soviet model of the mid-1950s – mid1960s
Uzbekistan	Export of raw cotton and metals	None	Labour surplus in agriculture	Slightly modified from the Soviet model

Like Kazakhstan, Kyrgyzstan, Tajikistan and Turkmenistan, Uzbekistan is actively developing its mining sector, primarily, gold and uranium extraction, which, together with cotton production, make a major contribution to the national economy and enable the inflow of hard currency. Uzbekistan also aims to develop its gas and oil extraction to meet domestic and export needs. The country's manufacturing output relies greatly on export-oriented cotton production and the fuel and energy sector.

**Table 1.9**  
Key characteristics of economic development of Central Asian states

Source: Zhukov, Reznikova, 2001: 488

Central Asian countries have been rapidly entering the global economy by establishing trade and economic ties with 192 countries. Growing export prices used in mutual trade and a price increase on world markets were a direct result of liberal foreign trade. The 1996–2010 period marked an upsurge in foreign trade transactions with the CIS countries, in particular, by 3.9 times in Kazakhstan and by 4 times in Kyrgyzstan. At the same time, the export of raw materials to other countries of the world is an important source of currency supply for Central Asian states rich in energy and mineral resources

(CIS, 2011: 101-106). This results in a continued reduction in the ratio of exports to the CIS and Central Asian markets. Nevertheless, Russia remains the leading trade partner for most Central Asian states due to the region's remoteness from the developed centres of economic and trade activity. This makes it economically reasonable to strengthen regional cooperation with neighbouring states within the CIS and EurAsEC frameworks (CIS, 2011: 196).

It should be noted that the natural resources sector has developed through direct foreign investment and/or loans, while R&D and education have been poorly integrated in innovative development programmes. All Central Asian nations lack funds for investment, which is one of the main factors hampering infrastructure development and upgrade of water, irrigation and energy infrastructure in particular. At the same time, the technical improvement of agriculture will lag behind food security targets in the future. According to demographic estimates, the population of Uzbekistan will grow to 35 million, Kazakhstan to 22 million, Tajikistan to 11 million, and Kyrgyzstan and Turkmenistan to 8 million by 2050. Despite the structural changes in the Central Asian economies, agriculture still consumes the bulk of water, while agricultural water needs will continue to grow unless the renovation and upgrade of water and irrigation facilities is carried out. All of these factors will be decisive in the interstate division of water use and determine water needs in the future, as current rates of water use already exceed the available water resources.

### 1.3. Regional water challenges in Central Asia

The regional water challenges in Central Asia include air and water pollution, flooding and drought, hazardous waste from the mining industry, and the degradation of land and mountain ecosystems. Altogether, they determine the sustainability of river ecosystems and safety of water use by underlining the need for integrated water resources management both at the national and regional level.

**The Caspian Sea** is the largest enclosed inland body of water on the border of Europe and Asia. Geographically, the coastlines of the Caspian Sea are shared by several countries, which as Russia, Azerbaijan, Kazakhstan, Turkmenistan and the Islamic Republic of Iran. The Caspian Sea is joined to the global ocean through artificial water courses. Its catchment area is eight times larger than the sea itself, which makes it prone to pollution from various external sources.

The late 1980s-1990s saw a high rise in the sea level followed by inundation and water-logging of seaports, industrial facilities, agricultural land, recreational areas, communications, and oil fields. It is noteworthy that the level of the Caspian has fallen and risen, often rapidly, many times over the



**Figure 1.10**  
The Caspian sea

Source: UNEP, 2008: 14

centuries. The main factor affecting the sea level fluctuations is believed to be changes in the climatic conditions, particularly in the Volga basin, which provides 80% of the inflow. Despite long-term observations, the understanding of specific triggers of the sea level variations is still limited and inadequate to be able to make a reliable long-term forecast. As a result of the development of the sea, coastal areas and catchment basins of the inflowing streams, the environmental issues of the Caspian are diverse in number and nature. Losses in oil and refinery products during extraction, transportation and use reach 2% of the total volume. Low technical quality, obsolete equipment and pipelines cause accidental spills and irrecoverable environmental damage. With the oil production expected to reach 70-80 million tonnes a year and losses at 0.1% or 80,000 tonnes, the environmental situation on the Caspian Sea may turn into an environmental crisis. This calls for the state-of-the-art oil extraction and transportation technologies that minimise loss and accidental spillage into the sea to zero.

The environmental sustainability of the Caspian Sea depends largely on the water quality of the inflowing rivers. Annually, over 2-5 tonnes of hard

metals, 62-146 tonnes of oil products and around 4.5 million tonnes of biogenic pollutants are discharged into the river deltas. The current sea level causes the pollutants to accumulate into bed silt in delta streams and waterways. This is one of the main factors of the Caspian environmental crisis, since almost all rivers have, more or less, turned into channels carrying pollutants to the Sea.

**Lake Balkhash** is one of the largest natural bodies of water in the world. Its length is 614 km, average width 30 km (70 km in its widest part), and average depth 5.8 m. The lake has an area of 17,800 km<sup>2</sup> and a volume of 90 km<sup>3</sup>. Balkhash is a closed lake with its entire inflow evaporating.



**Figure 1.11**  
Lake Balkhash

Source: UNECE, 2011b: 125

Inflow to the lake includes surface and underground water runoff from the coastal strip and precipitation. The Ili River, which is formed in China's territory, plays a key role in the lake's water balance.

A narrow strait of Uzun-Aral divides Balkhash into two isolated parts with very different regimes. The western part covers 10,540 km<sup>2</sup> of the total lake area and is relatively shallow (not deeper than 11 m). The eastern part covers a smaller area (7,440 km<sup>2</sup>) but is deeper (up to 26 m in depth). The Uzun-Aral Strait is about 2.5 m deep and 5 km wide. The dissolved solids concentration in the water of the eastern part goes over 4 g/L, while a high inflow of relatively fresh water from the Ili River make the water in the western part nearly fresh with the content of total dissolved solids about 0.5-5 g/L. The currents in the strait are variable and multidirectional, and depend on the wind direction and seiche fluctuations of the lake level. The exchange of water between the western and the eastern parts via Uzun-Aral Strait accounts for the changes in the salinity level and salt load of water with more water carried from the western part to the eastern part than the other way around. The difference between the flows averages to 1.15 km<sup>3</sup> per year. The intensity of

water exchange or cross flow volume varies depending on inflow and affects the salinity of the western part of the lake.

A peculiar characteristic of the lake is that its western part is the only source of water for the population and industry of the Balkhash region, while the rivers crossing the lake basin are the main source for irrigated agriculture. The basin has a number of water reservoirs, which serve to increase the irrigation capacity of the water sources, and small reservoirs located in the area of the Big Almaty Canal are used for water supply. Kapchagay, built in 1970, is the largest reservoir on the Ili River. It is used for energy-generation, irrigation and recreational purposes.

Human activities such as the intensive use of water, land and other natural resources both in the Chinese and the Kazakh areas of Balkhash Lake basin seriously disturb the natural balance of the lake and the Ili delta and are causing the environmental deterioration of the entire basin. The water supply of a significant area of the lake system has discontinued, while at times the level of the lake has fallen below the permissible water level of 314 m. This was a key factor in the decision to reduce the fill level of the Kapchagay Reservoir from its designed volume of 28 km<sup>3</sup> to 16-18 km<sup>3</sup>. At the same time, a further factor was the rate of development of irrigated agriculture and water use from the streams flowing into Balkhash. The conflicting interests of water energy generation and irrigated agriculture and the need to conserve the regime and the salinity balance of the western part of Balkhash as the main source of water require a comprehensive set of actions to be taken jointly with China to ensure the inflow of the Ili River to the lake, prevent pollution of the lake and maintain a sustainable ecosystem in the catchment basin.

**Lake Issyk-Kul** is one of the deepest lakes in the world. It has a depth of up to 702 m, covers an area of 6,249 km<sup>2</sup> and holds a volume of 1,730 km<sup>3</sup>.



**Figure 1.12**  
Issyk-Kul Lake

Source:  
Zoi Environment  
Network, 2011: 44

The lake water is fairly saline; water transparency reaches 12-16 m in depth in the open part of the lake. Located in the central Tien Shan at an altitude of 1,609 m, Issyk-Kul is an endorheic lake. About 80 relatively small rivers flow into the lake; the largest of these are the Djyrgalan and Tyup. The lake has an important recreational role and is one of the key water bodies for international tourism and recreation.

The main challenge that needs to be addressed and requires external investment is the balance between the recreational capacity of the lake and its coastline and the human-induced load during mass leisure periods, elimination of discharge of wastewater by coastline hotels, guesthouses and health resorts.

**Problems around Lake Sarez.** Of serious concern for the region are natural disasters such as earthquakes, flooding, land sliding, and mud flows, all of which undermine the safety of dams and water reserves, human settlements and urban areas along the rivers of Central Asia. The destruction of any large dam will adversely impact the nations of the region. The points of greatest concern in this respect are mountain areas of Tajikistan and Kyrgyzstan that feed the bulk of the river runoff and are most prone to disastrous flooding.

Lake Sarez was formed in a narrow mountainous basin after a landslide caused by an earthquake, estimated at 9.0 on the Richter scale, which occurred in the

Lake Sarez (physiographic parameters)	Value
Multiyear annual average temperature	1 °C
Average temperature in January	13.9 °C
Average temperature in July	14.7 °C
Annual average precipitation	135 mm
Annual average surface water flow	1.48 km <sup>3</sup>
Annual average outflow	1.44 km <sup>3</sup>
Water-surface area	80 km <sup>2</sup>
Length	60 km
Overall width	3.3 km
Average width	1,5 km
Maximum depth	505 m
Average depth	202 m
Coastline	162 km
Water volume	17 km <sup>3</sup>
Range of annual water level fluctuations	3–12 m
Design height of wind-generated wave (Once per 100 years)	2 m
Duration of ice cover	4–4.5 months
Ice cover depth	0.6–0.7 m

**Table 1.10**  
Physiographic  
parameters of Lake  
Sarez

Source: RT,  
2001: 109-110

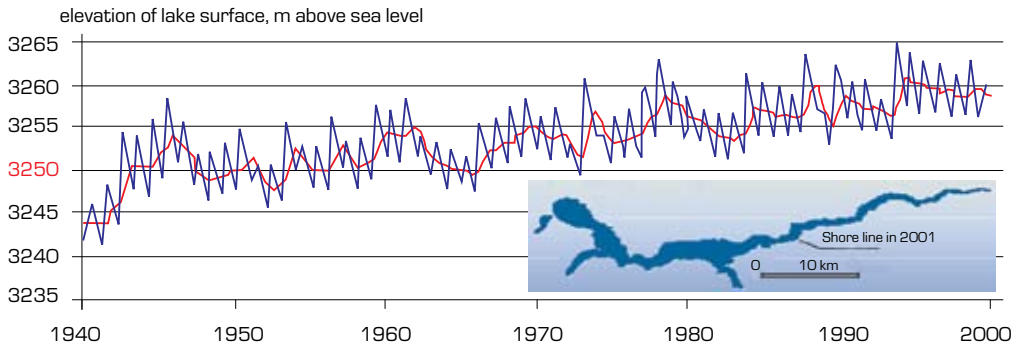
Murghab river valley in February 1911. The earthquake caused destruction and deaths in Murghab, Shugnan, Rushan, Ishkashim, Khorog and other villages located in the Gunt and Panj river valleys. The size of the disastrous landslide became known only much later, in 1915, when Russian scientists made a detailed site survey. Today, the depth of the lake reaches 505 m and it has a volume of 17 km<sup>3</sup>.

Research carried out between 1968 and 1997 suggested that in addition to the periodic fluctuation of the lake level caused by climate factors and geotectonic processes occurring inside and on the surface of the collapsed body of earth and rock, a huge mass of rock could fall into the lake from the banks of the Sarez valley. However, the main possible trigger of a rise in the lake level would be a landslide or landfall caused by an earthquake. Sarez Lake is located in a seismically active zone, confirmed by the number of great earthquakes in this part of the Pamir. Between 1940 and 1980, the area went through 25 earthquakes estimated at 5 and 3 at over 7 on the Richter scale recorded in 1941, 1949 and 1963 respectively. June 29<sup>th</sup> and August 12<sup>th</sup> 1975 were marked by earthquakes estimated at 4-5 on the Richter scale that caused a great number of landslides into the lake. The limited information available about the hydrological regime of Lake Sarez (with 50% of the catchment basin not engaged in hydro meteorological surveys) makes it difficult to forecast accurately and establish a link between the lake level fluctuations and geological and hydro meteorological factors and climate changes.

International involvement is needed to tackle the problems around Lake Sarez. Priority should be placed on the safety of the population, routine monitoring of the dam, an effective warning system and improving transport infrastructure for emergency evacuation. At the same time, it makes sense to use the unique recreational potential of Sarez Lake for international tourism and leisure. Sarez has the potential to be the world's largest source of drinking water, and could supply Central Asia and other regions that do not have access to safe drinking water.

The lake lies at an altitude of 3,239 m and has a depth of up to 500 m, an area of 80 km<sup>2</sup> and a volume of 17 km<sup>3</sup>. The ability of the natural dam to continue to retain this colossal mass of water at such a high altitude is questionable, which is understandable given how the dam came about.

The Pamir is one of the most earthquake-prone regions in the world. The landslide dam continues to crack, crater and hole, as a result of natural contractions, minor earthquake vibrations and temperature conditions. The unstable slope of the lake sliding and rocks weighing over 1 billion km<sup>3</sup> would give rise to a 150-200 m disturbance wave and destroy the dam causing the Sarez Lake to be destroyed. An estimated 52,000 km<sup>2</sup> of the territory of Tajikistan, Uzbekistan, Turkmenistan and Afghanistan, home to 5 million



**Figure 1.13**

Water level in Lake Sarez, Central Pamirs

Source: RT, 2008: 43

people, would be affected if a disastrous mudflow were to travel through the Bartang, Panj and Amu Darya valley. Solutions to the challenges posed by the Sarez Lake, including the effects of the dam being destroyed and the need for massive financial resources, should be sought in the context of regional security, which requires coordinated action of the international community.

The regional environmental challenges in Central Asia are linked to the shrinking Aral Sea, the pollution of the Caspian Sea, Lake Balkhash and other water bodies with hazardous waste from the mining industry, air and water pollution, land and ecosystem degradation as well as flooding and drought threats. All of these affect the sustainability of the river ecosystems and safe water management and condition environmental cooperation. Thus, for example, during the Soviet period the Ferghana Valley was a hotspot for nearly 50 multi-metal and uranium mining fields. Tailing pits left behind by operating and non-operating mining companies also pose an environmental and security threat. Many tailing pits, salt and slurry repositories were built in the floodplains of rivers that make a major contribution to the transboundary subsurface runoff. Taking into consideration the poor state of preparedness for a disaster, the contents of the repositories may flow into the rivers. The proximity of the repositories to stream flows, urban areas and national borders makes the effects of possible emergencies a transboundary problem that threatens the water use, health and safety of the population.

**Challenges faced by the Aral Sea.** Like any water body without drainage, the Aral Sea was a self-regulating system with the sea level depending on the inflow-outflow fluctuations. The Sea lost its self-regulating capacity within an incredibly short period of time when the balancing natural and hydrological factors were no longer sufficient, which was a result of the intensive development of new lands and the use for the irrigation of less productive lands at a significant distance from the river bed, located at higher altitudes. Therefore, the problems of the Aral Sea stem mainly from unsound water use.



## Chapter 2. Water resources and irrigational development in Central Asia

### 2.1. Water resources management in Central Asian states

Most of the territory of **Kazakhstan** lies in the endorheic basins of the Caspian and Aral Seas, lakes Balkhash, Tengiz, Alakol and others that do not drain into the world's oceans. Geographically, Kazakhstan can be divided into eight water basins, which are Aral-Syr Darya, Shu-Talas, Balkhash-Alakol, Irtysh, Ishim, Nura-Sarysu, Tobol-Torgai and Ural-Caspian basins.

The surface water resources in an average water year total 100.5 km<sup>3</sup>, of which 56.5 km<sup>3</sup> are formed domestically and the remaining 44 km<sup>3</sup> come from neighbouring countries. Specifically, 18.9 km<sup>3</sup> from China, 14.6 km<sup>3</sup> from Uzbekistan, 3 km<sup>3</sup> from Kyrgyzstan, and 7.5 km<sup>3</sup> from Russia. 63.8% or 173.91 million ha of Kazakhstan's area lies in international basins. The current estimates of Kazakhstan's river runoff are less than earlier estimates. A reduction in the surface runoff suggests a significant climatic and human-induced impact on water resources and indicates a stable downward trend in the volume of surface water resources. The water supply level averages 20,000 m<sup>3</sup> per 1 km<sup>2</sup>, or 200 m<sup>3</sup> per 1 ha, which is one of the lowest indicators in Eurasia. Surface water is unevenly distributed throughout the territory of Kazakhstan with 34.5% of surface water accumulated in eastern, 4% in northern, 2.6% in central, 24.1% in south-eastern, 21.2% in southern, and 13.4% in western Kazakhstan. The return water volume is about 4 km<sup>3</sup>, of which 2 km<sup>3</sup> of water returns to water sources, and the remaining flow is dispersed or lost.

Kazakhstan's water power potential is estimated at 11 GWh per year, and its economically justified potential at about 35 GWh per year. Water power accounts for approximately 12% of all power generated in the country. Irrigated land occupies 2.3 million ha or 6.4% of all arable lands. The area of actually irrigated land has, however, shrunk. There are 214 water reservoirs, which hold a total water volume of 95.5 km<sup>3</sup>, without including ponds and small water reservoirs of local significance. The majority of these, 116, have a volume of 1-5 million m<sup>3</sup>, and 95 have a volume of 5-100 million m<sup>3</sup> each. Most are seasonal storage reservoirs. Most of the large and medium reservoirs are multi-purpose and used for water power, transport and



**Figure 2.1**  
Map of Kazakhstan

Source: ADB, 2010: 31

irrigation needs. There are about 340 water power installations and facilities that serve the water supply system. Almost all regions of the country have underground water reserves, which, however, are unevenly distributed and differ by quality and volume. Underground water is used at the rate of 11.3% or 1.7 km<sup>3</sup> per year. The bulk of underground water reserves, about 50%, are in southern Kazakhstan. Up to 20% of the reserves are formed within western Kazakhstan. Central, northern and eastern Kazakhstan accounts for 30% of all underground water reserves.

There are over 2,000 water pipelines across Kazakhstan's urban areas, oblast and rayon centres and rural areas. Most of these pipelines were installed or properly repaired over 25-35 years ago. In urban areas and smaller settlements the water supply and sewage disposal services are provided by water service companies. This sector is decentralised and under the authority of local authorities (municipalities).

The national water resources management system includes national authorities and local representative and executive authorities responsible for water resources management; the Water Resource Committee under the Ministry of Agriculture, which is an authorised national agency for water use and conservation; other national authorities working with water management authorities on issues pertaining to water resources use and conservation.



**Figure 2.2**  
Kazakhstan river  
basins  
Source: UN,  
2008: 142

Kazakhstan has developed basic environmental laws, including the new Water Code of 2003 and signed a number of international agreements and conventions on the use and management of water resources. The country has an operational system for water conservation and national register and maps of water pollution sources. At the same time, a system of payments for water supply services, water resources use and water pollution is under development.

Drinking water supply issues are addressed in the context of national security. In order to achieve this, the sector programme “Drinking water” was adopted.

Further fine-tuning of the environmental laws and the environmental management system was prioritised via a number of important presidential resolutions during 1997-1998. It was also incorporated in Kazakhstan’s Development Strategy up to 2030 and the Action Plan for the Government of the Republic of Kazakhstan. According to Kazakhstan’s Development Strategy up to 2030, environmental conservation and management is a long-term priority, and the government plans to improve the funding of environmental management efforts, promote the national contribution to international environmental policies and enable the use of environmentally friendly technologies. Issues such as water resources conservation, sustainable use of water resources, integrated water resources management, improving the quality of drinking water and the water supply of southern and western Kazakhstan were prioritised.

The main area of development to build the capacity of the water sector will be to increase the available water resources by regulating river runoff through water development facilities such as canals and reservoirs and using underground water. In regions suffering from an acute deficit of fresh water, small and medium sized desalination plants will be installed to process abundant deep-flowing reserves of brackish and saline groundwater. Other areas include introducing water-saving technologies, improving the user-pays mechanism for water use; taking advantage of loans and grants of both international and national financial organisations to promote the sustainable use and conservation of water resources; using international and national best practices and techniques to treat polluted water, and to prevent the depletion, pollution and contamination of water; and, improving the quality of professional training of specialists to work in water facilities and water infrastructure design organisations.

**Environmental situation.** Relatively limited water resources, unequal geographical distribution of water and highly polluted water bodies are the factors hampering water supply to the population, water use in different sectors of the economy and ecological sustainability of the environment, all of which constitute the most serious barrier to the sustainable development of the country. The quality of surface water in almost all water bodies is below the standard quality of river water. Transboundary discharges are the main source of pollution for the major rivers. The waters of the Irtysh, Ili, Ural, Syr Darya and other rivers that form in neighbouring countries reach Kazakhstan already polluted. Polluted sources and the unsatisfactory health of water supply facilities contribute to growing infection rates and undermine health and disease control. Additional negative factors include the need for urgent measures to ensure safety of water facilities, distribute the water resources of transboundary rivers, counteract and mitigate flooding as well as the lack of transnational monitoring of water resources and exchange of reliable data regarding the use of water resources, and mutual emergency warning systems for water facilities installed on transboundary rivers.

A number of large regions in Kazakhstan have a negative environmental situation. These are the areas around the Caspian Sea and the Ural River as well as the former Semipalatinsk nuclear testing site. The Aral Sea and the former Semipalatinsk nuclear testing ground located within Kazakhstan territory contribute to the ongoing environmental crisis and have an adverse effect on the socio-economic situation of both Kazakhstan itself and its neighbours. The Caspian Sea, Balkhash, Tengiz and other lakes are basins accumulating polluted river runoff, which poses major environmental risks. In particular, the negative environmental impact is the pollution of river runoff of transboundary rivers, including the Irtysh, Ili (China), Syr Darya (Uzbekistan), Shu, Talas (Kyrgyzstan) and the Ural (Russia).

As a result of unregulated agricultural and mining activities, a significant share of the country's land has been exposed to desertification processes: a deterioration of green cover, soil blowing, water erosion, soil salinification and pollution from industrial waste and toxic chemicals. Human-caused desertification predominates in industrial production areas and the construction of transport and engineering infrastructure. Large industrial centres such as Pavlodar, Ekibastuz, Karaganda, Temirtau, Karatau, Zhambyl, and western and eastern Kazakhstan are most polluted with mining waste and byproducts from the processing of minerals containing uranium. 5.2 of the 21 billion tonnes of industrial waste accumulated in Kazakhstan are toxic. The pool of toxic waste grows by 92 million tonnes every year, of which 60% is mineral waste. The mining industry has left behind waste dumps with a mass of 4 billion tonnes and over 1.1 billion tonnes of refuse ore and mineral enrichment waste. Furthermore, air pollution results from ineffective environmental measures taken by power producers, transport, fuel and metallurgical production. Zinc and lead production facilities based in and around Ust-Kamenogorsk and chrome producing facilities based in Aktobe are the main sources of air pollution emissions in Kazakhstan. Motor vehicles also have an adverse effect on the quality of air in urban areas. In most large cities motor vehicles account for over 60% of air pollution emissions; in Almaty the indicator reaches 90%.

**Kyrgyzstan** is a mountainous country. 94% of its territory lies at an altitude of over 1,000 m and 40% at over 3,000 m above the sea level, and 4% is covered with glaciers. The country's water reserves are estimated at 2,458 km<sup>3</sup>, of which 1,745 km<sup>3</sup> is lake water, and 650 km<sup>3</sup> is glaciers. Total surface river runoff reaches 50 km<sup>3</sup>, and groundwater reserves total 13 km<sup>3</sup>. There are 1,923 natural lakes with a combined surface area of 6,800 km<sup>2</sup>, of which the largest is Issyk-Kul, which is the second largest lake of volcanic origin in the world. There are over 3,500 rivers that feed the three main endorheic basins, which are the Aral Sea (76.5%), Lake Issyk-Kul (10.8%), Lobnor (the Tarim River 12.4%) and Lake Balkhash (0.3%).

The area where river runoff is formed (the mountains) covers 171,800 km<sup>2</sup> or 87% of the country's territory, and the area of runoff water dispersion covers 26,700 km<sup>2</sup>, which accounts for 13% of the national territory. The total river runoff is estimated at 47.2 km<sup>3</sup>. When both return water and runoff water of "karakasu"-type sources are included, available surface water reserves total 50 km<sup>3</sup> in an average water year. Known and approved reserves of fresh groundwater of 34 fields equal 3.5 km<sup>3</sup> per year. Potential reserves, however, reach 13 km<sup>3</sup>. Kyrgyzstan uses 20% of the surface water formed within its territory with over 80% remaining as transit flow ending up in downstream river basins in Uzbekistan, Kazakhstan, China and Tajikistan. Uzbekistan uses about 50% or over 22.1 km<sup>3</sup> of



**Figure 2.3**  
Map of Kyrgyzstan

Source: ADB,  
2010: 35

this transit flow water. International basins account for 17.06 million ha or 85.3% of the territory of Kyrgyzstan.

18 large water reservoirs were built to control transboundary river runoff such as the Chu, Talas, Naryn, Ak-Bura and Kara Darya. The largest reservoirs are Toktogul of 19.5 km<sup>3</sup>, Kirov of 0.55 km<sup>3</sup>, Orto-Tokoi of 0.47 km<sup>3</sup>, Papan of 0.26 km<sup>3</sup>, and Nizhne-Ala-Archa of 0.26 km<sup>3</sup> in volume. There are six reservoirs in the Chu river basin, three in the Talas river basin and nine in the Syr Darya river basin with a total volume of 0.6, 0.6 and 22.3 km<sup>3</sup>, respectively. Thus, the controlled river runoff is 23.5 km<sup>3</sup>, which makes up 47% of surface water reserves.

Agricultural land occupies 9.34 million ha, of which rangeland accounts for 7 million ha. 1.34 million ha are under cultivated land, of which irrigated land accounts for 1.06 million ha. In 1943 irrigated land occupied no more than 0.43 million ha. Most of the irrigated lands are in the Syr Darya river basin (42%), the Talas and Chu river basins (41%) and around Lake Issyk-Kul.

Annually, 6.5 km<sup>3</sup> of water is consumed, of which water for agricultural needs accounts for 5.96 km<sup>3</sup>, water for industrial needs for 0.13 km<sup>3</sup>, and water for domestic needs for 0.31 km<sup>3</sup>. 30% of rural and 14% of urban population have no access to drinking water. The sewage system is accessible to 51% of the urban population and only 3% of the rural population. The remaining population has access to completely unsatisfactory water supply services due to the

poor condition of the water pipelines and obsolete water treatment facilities or a lack of these. There are about 1,750 rural settlements, of which half have limited access to water facilities. At the same time, the limited capacity of rural population to pay for water supply services and lack of government allocations hinder the maintenance and renovation of water facilities. In many communities, people are forced to use water from irrigation canals. To tackle the water supply related issues the government is making use of foreign investment resources. By 2015-2020, it is expected that 93% of the urban population and 85% of the rural population will have access to a safe water supply system, and that 76% of the urban and 52% of the rural population will have access to the sewage system.

The national Water Code guiding water resources use, protection and development relations lays down the basic principles of water resources management and respective government policies. It also defines measures to protect water resources from pollution and depletion and ensure dam safety. At the national and local levels water resources management and the regulation of intersectoral water relations are under the mandate of the Parliament, the Government and the local representative authorities. In December 2011 the executive authorities that were part of the Government of the Kyrgyz Republic were restructured, including government water authorities. The Ministry of Agriculture of the Kyrgyz Republic and the National Water and Land Reclamation Committee of the Kyrgyz Republic were reorganised into the Ministry of Agriculture and Land Reclamation of the Kyrgyz Republic with the Ministry of Energy and Industry of the Kyrgyz Republic taking over the responsibility of managing the river basins with existing and new water power stations.

The Department for Water Management and Land Reclamation under the Ministry of Agriculture and Land Reclamation of the Kyrgyz Republic took over the mandate to manage water resources and water services. The Department is part of the Ministry and is responsible for the management, monitoring and control of the status and use of water resources, irrigation and land reclamation facilities and has executive, administrative and coordinating authorities to ensure integrated water policies.

Water power engineering has an important role in the national economy. Kyrgyzstan has significant water power resources that can be developed. All Kyrgyz water power stations were set up to serve multiple purposes, such as irrigation and power production, and taking into account the interests of other states in the region. In this respect, Kyrgyzstan has a leading role in the creation of a common water power market in Central Asia.

The main barriers to the country's sustainable development include growing competition for water between the water power sector and agriculture both

at the interstate level and the national level. Other water-related factors that contribute to the deteriorating socio-economic situation in Kyrgyzstan include the safety of the dams and unsatisfactory urban and rural water supply. Of particular risk is the operation of high-head dams because centralised control over the status of hydraulic structures is no longer exercised. Regional cooperation should focus on averting the threat of potentially hazardous transboundary accidents at the sources of rivers close to the storage of highly toxic and radioactive mining waste. The quality of water of transboundary rivers can be viewed as a regional challenge affecting safe water use in the countries that neighbour Kyrgyzstan. The countries lying in the Syr Darya, Chu and Talas river basins are likely to compete more fiercely for water due to the rapidly changing water balance in neighbouring countries, the terms under which water is used by the involved parties and economic development priorities. Disputes over the apportioning of transboundary river water are more likely to arise during low-water periods, which may last up to several years. This requires a coordinated action plan for the integrated water resources management of transboundary rivers.

**Environmental situation.** A significant part of the territory of Kyrgyzstan is represented by a high, mountainous ecosystem, which is particularly vulnerable to human intervention that affects even the sparsely populated Pamir and Tien Shan. Kyrgyzstan is also prone to such disasters as earthquakes, landslides, mudflows, flooding, etc. Climate change and the pollution of mountain ecosystems goes hand in hand with shrinking glaciers and transboundary river flow. This factors into the regional water resources deficit and becomes a serious challenge for interstate relations in Central Asia. Over the past fifty years, more than 1,080 glaciers have disappeared from the region. Kyrgyzstan's transboundary river basins are homes to a large number of waste deposits left after polymetallic and radioactive ore processing. These deposits may fall apart, in which case the ecological catastrophe may impact Kazakhstan, Uzbekistan and Tajikistan.

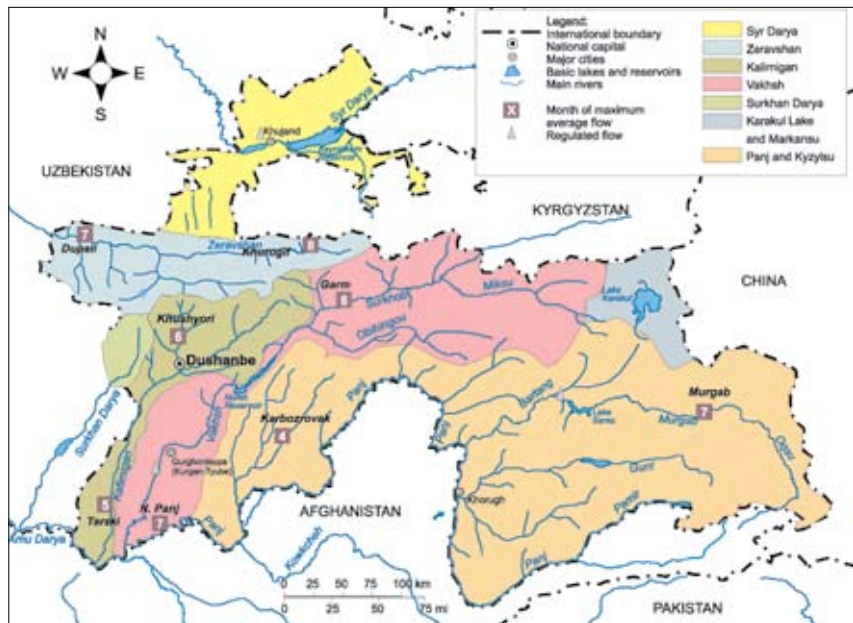
Hydrographically, there are four main river basins in **Tajikistan**. To the north-west is the Syr Darya river basin where the Khojabakirgan, Aksu and Isfara rivers feed surface runoff water with a volume of 0.4 km<sup>3</sup>/year or about 1% of total basin runoff. To the south is the Amu Darya river basin represented by the Vakhsh, Panj and Kafirnigan rivers, which contribute 82.5% of the total basin water reserves.

600 rivers and temporary streams start in Tajikistan. Average multiyear runoff formed within the territory of Tajikistan reaches 61.8 km<sup>3</sup>, of which the Amu Darya basin accounts for over 98%. 99% of total surface runoff starting in Tajikistan is transboundary water. 1.4 million ha or 9.8% of the country's area lies in international basins. Renewable groundwater reserves total 6 km<sup>3</sup>, of which 3 km<sup>3</sup> are hydraulically linked to surface runoff. 60%

of groundwater feeds river runoff in Tajikistan's share of the Syr Darya basin and 20% in the Amu Darya basin. The volume of return water in Tajikistan is large, reaching  $4.36 \text{ km}^3/\text{year}$ , of which collector and drainage water flowing from irrigated land accounts for  $3.78 \text{ km}^3/\text{year}$  and domestic and industrial waste water for  $0.58 \text{ km}^3/\text{year}$ . Most of the return water, about  $3.94 \text{ km}^3/\text{year}$ , flows back into the rivers, of which  $2.85 \text{ km}^3$  flow into the Amu Darya and  $1.09 \text{ km}^3$  into the Syr Darya. Over  $0.35 \text{ km}^3/\text{year}$  or 8% of all return water is re-used for irrigation purposes. A total of  $12\text{--}14 \text{ km}^3$  of water is used in different sectors of the economy, of which irrigation accounts for  $9\text{--}10.5 \text{ km}^3$ .

$8,400 \text{ km}^2$  or 6% of the territory of Tajikistan is under glaciers and permanent snow cover, most of which are in the Pamir Mountains. There are about 8,000 glaciers in Tajikistan, of which 7 are over 20 km in length. Glaciers and snow beds store large water reserves, totaling about  $460 \text{ km}^3$ . The Fedchenko Glacier is the largest in Central Asia. The glacier begins at an elevation of 6,200 m above sea level and ends at an elevation of 2,910 m. It extends for over 70 km and has an average width of 2 km. The maximum thickness of the glacier is 1 km, and the volume of the Fedchenko and its tributaries is estimated at around  $140 \text{ km}^3$ .

Tajikistan is home to 1,300 natural lakes with total combined fresh water reserves of  $50 \text{ km}^3$  and an area of  $705 \text{ km}^2$ . 78% of the lakes are at an altitude of 3,500 m above the sea level. Tajikistan has a continental climate, which, however, differs dramatically in the mountains and plains.



**Figure 2.4**  
Tajikistan river basins

Source: UN,  
2004: 105

Average annual precipitation is 691 mm ranging from 100 mm in the south-east to 2,400 mm on the Fedchenko Glacier in the centre of the country. Most of the precipitation falls in winter, between September and April.

The country has 19 water reservoirs, five of which are in the Syr Darya basin and 14 in the Amu Darya basin. The reservoirs have a total storage capacity of 29 km<sup>3</sup> and cover an area of 934 km<sup>2</sup>. Nine are large reservoirs with a storage capacity of 0.5 km<sup>3</sup> each and a total storage capacity of 25.34 km<sup>3</sup> covering an area of 690 km<sup>2</sup>. The largest reservoirs are the Nurek Reservoir on the Vakhsh River with a storage capacity of 10.5 km<sup>3</sup>, the Kayrakkum Reservoir on the Syr Darya with a storage capacity of 4.16 km<sup>3</sup>, and the Nizhne-Kafirnigan Reservoir on the Kafirnigan River with a storage capacity of 0.9 km<sup>3</sup>.

Tajikistan has great water power potential, which is being developed slowly due to the lack of significant foreign investment. Water power accounts for 97% of all electric power generated in the country.

Tajikistan has very limited land suitable for agricultural use. The area of cultivated land is no more than 769,900 ha, of which 720,000 ha are under irrigated land. 240,200 ha, which is 33% of the country's irrigated land, is in the Syr Darya basin, 479,000 ha or 67% of total irrigated land is in the Amu Darya basin, of which 392,000 ha in the Vakhsh river basin, 49,000 ha in the Kafirnigan river basin, 20,000 ha in the Zeravshan river basin and 18,000 ha in the Panj river basin.

Annual water use totals about 11-11.5 billion m<sup>3</sup>, of which 4% is for domestic use and drinking water, about 6% for industrial production, around 89% for irrigation and around 5% for other agricultural needs. The majority of the water, 89%, is used for irrigated farming.

The country's territory is in a zone of high seismic activity. This dictates special standards for the safety of dams and water reservoirs and demands routine monitoring of natural lakes, many of which were formed as a result of tectonic processes and earthquakes.

Today's water utilisation system in Tajikistan is made up of a set of unique complex hydraulic engineering structures. The register of the Ministry of Land Reclamation and Water Management includes an irrigation network that is 5,896 km in length, of which 1,730 km has concrete lining, 124 flumes, pipelines – 38 km in length, collectors and drains – 2,300 km in length, 7,775 hydraulic structures, 2,133 well holes, 517 pumping stations, power transmission lines – 288 km in length, 2,580 electric substations, phone lines – 58 km in length, tunnels - 26.6 km in length, roads – 3,272 km in length and other funds.

Despite Tajikistan's ample water reserves, supplying safe and high-quality drinking water remains a serious problem, particularly, in urban areas. Most urban and rural water supply and sewage facilities are unsatisfactory and require immediate rehabilitation of the treatment plants and capital repairs to the water transmission and distribution network.

More than 30% of the existing urban and rural water supply facilities are not operational due to engineering malfunctions and physical depreciation.

Flood hazards in Tajikistan include mudflows and the breach of mountain lakes, in particular, debris flow close to unprotected waste repositories that remained following the extraction of mercury, antimony, uranium, etc.

Lake Sarez is a major hazard in Central Asia. It requires Tajikistan to team up with the international community to ensure the effective monitoring of mountain lakes and anticipatory action in order to maintain adequate safety levels.

The Ministry of Land Reclamation and Water Management is a national water authority with a vertical hierarchy of community-based divisions. It should be noted that the Ministry supports a highly centralised water management style and sometimes engages in administrative issues that are more typical of lower level divisions. With the practices in place, farm enterprises have limited authority to distribute water based on consultations with water user associations and have little incentive to effectively maintain on-farm irrigation networks and water facilities.

In the context of the over-centralisation of management authorities by the Ministry, strategic planning and integrated water resources management issues are overlooked. Concentrating political and management decision making at the national level and the lack of clear division of authorities and responsibilities between hierarchical structures and the government authorities involved in water relations are common to all Central Asian states. The national water resources management policies and water use strategies are based on a weak legal and institutional framework, which hampers water sector reforms as well as effective regional cooperation for the shared use and protection of transboundary rivers.

In 2001, the Government of the Republic of Tajikistan approved the Concept for Sustainable Water Resources Use and Management, which defines the key development areas for the water sector and, in particular, institutional and legal arrangements. The entire water sector largely depends on the decisions respective institutions make regarding water resources management and the implementation by institutions within the existing legislative framework. In Tajikistan water relations are guided by the Water Code adopted in November 2000, regulatory legal acts and ratified international instruments.

**Environmental situation.** The territory of the country is highly seismically active, which results in special standards being required for the safety of dams, water reservoirs and natural lakes. Ineffective agricultural practices, such as the development of steep mountainous slopes, have caused erosion, affecting 60-70% of the agricultural land.

**Turkmenistan's** water reserves total 23.94 km<sup>3</sup> and consist of the surface runoff of the Amu Darya, Murghab, Tejen and Atrek rivers, minor streams flowing from the north-eastern slopes of the Kopet Dag Range as well as inconsiderable groundwater and collector and drainage water. Surface water accounts for 97.5-98.2% of all water reserves. The surface water is formed outside Turkmenistan and is of transboundary nature. 5.3 million ha or 10.8% of the country's territory lies in international basins.

Groundwater intake is 474 m<sup>3</sup>, of which 45% is used for domestic and drinking needs, 30% for irrigation, and 25% for flooding of pastures and health resorts. Collector-drainage flow from irrigated land coupled with treated industrial, municipal and domestic waste water make up 6 km<sup>3</sup>, of which 47 million m<sup>3</sup> is used primarily for irrigation, with the figure included in national water reserves.

The Amu Darya River is the main source of water. 22 out of 63 km<sup>3</sup> of the river's total runoff remains in Turkmenistan. Water is drawn from the Amu Darya through the Kayrakum Darya Canal and is regulated with its three reservoirs with a total storage capacity of 2.4 km<sup>3</sup>. In 1998, the Amu Darya accounted for 22.0 km<sup>3</sup>; the Murghab River for 1.044 km<sup>3</sup>; the Tejen River for 0.232 km<sup>3</sup>; the Atrek River for 0.068 km<sup>3</sup>; small streams for 0.070 km<sup>3</sup> of a total of 23.414 km<sup>3</sup> of annual surface water runoff used for the needs of different sectors of the economy.

Every year the Amu Darya runoff water accumulated at the gate of the Kerki gauging station is equally divided between Turkmenistan and Uzbekistan based on an estimation of the water content of the river. The Tejen and Atrek river runoff is apportioned in accordance with an agreement signed by Iran and Turkmenistan in 1926. It provides for Turkmenistan's annual entitlement of 70% of the total average Tejen river runoff and 50% of the total average Atrek river runoff, which amounts to an average of 0.75 km<sup>3</sup> of the Tejen river runoff and 0.006 km<sup>3</sup> of the Atrek river runoff annually.

Turkmenistan is home to 18 water reservoirs with a total storage capacity of 2.89 annual km<sup>3</sup>, of which eight are on the Murghab River, three on the Tejen River, three on the Atrek River and 4 on the Kayrakum Darya Canal. The Khauz-Khan Reservoir on the Karakum Darya Canal is the largest and has a storage capacity of 0.875 km<sup>3</sup>. Agricultural water is distributed via farm ditches and on-farm canals.

The Turkmen Lake Altyn Asyr (Golden Age Lake), the country's most ambitious project, is a new water reservoir with a storage capacity of over 100 km<sup>3</sup>. Collector-drainage water flowing from irrigated land and part of the waste water discharged to desert basins, totaling 6 km<sup>3</sup>, as well as 5 km<sup>3</sup> of collector-drainage runoff coming from Uzbekistan primarily to the Sarykamysh Hollow will be channeled to the Turkmen Lake. Thus, all 11 km<sup>3</sup> of collector-drainage water runoff will be used to feed the lake.

Irrigation accounts for 91% of the country's water intake, industry for 7% and domestic and drinking water for 2% of the country's water intake.

Turkmenistan supplies water to the population free of charge. Therefore, access to water does not depend on income levels. Moreover, the government also covers the construction and maintenance costs of the water supply facilities. Over the past years, the government funded a number of drinking water bottling facilities, water-desalinating plants and water treatment facilities. The size of the government's investment in water facilities depends largely on the global prices of Turkmenistan's major export goods, which include natural gas, oil, cotton, and chemical raw materials, as well as on the national rate of market economy development.

The irrigation network is managed by the Turkmenistan Ministry for Water Management through its structural divisions based in all administrative units



**Figure 2.5**  
Map of Turkmenistan

Source: ADB,  
2010: 43

of all levels and by mirabs (local water authority) in individual communities. In Turkmenistan irrigation water is supplied free of charge within the (planned) fixed limit. Users pay for water used over the limit at three times more than the fixed cost.

A new Water Code was adopted in 2004. As in other countries of Central Asia, a national water management authority combines both the political and administrative mandate, while its authorities and responsibilities are poorly distinguished from the other national authorities and lower-level community-based structures.

**Environmental situation.** Turkmenistan lies in the Central Asian desert zone, characterised by an extreme climate. Northern Turkmenistan falls under the Aral Sea crisis zone. 90% of the country's territory has a desert relief. Turkmenistan's environmental issues are closely linked to agriculture. Currently, 30% of irrigated land is highly saline, and 50% of irrigated land has a medium salinity level. This results in a 50% reduction in crop productivity. On the national environmental agenda the top priorities are counteracting the soil salinification, rangeland degradation, desertification, and wind and water erosion. Water supply and irrigation are the key factors that have to be addressed in order to achieve sustainable development. Annually, Turkmenistan receives 100-150 mm of precipitation, most of it rainfall. Evaporation exceeds precipitation by 20 or more times, which underlies a great shortage of fresh water. River runoff is irregular and fails to meet the country's water needs. The quality of water is deteriorating because of contamination with untreated industrial and domestic waste water; some lands can no longer be used as a result of the human-caused environmental impact from the mining industry. Air pollution is growing due to the impact from chemical industry, production of building materials and energy generating activities. As in many other countries, inefficient management of hard domestic waste is a major contributor to environmental degradation in Turkmenistan.

Nearly all of **Uzbekistan's** rivers are transboundary. 80% of consumed water resources are fed outside the territory of the country. Its hydrographical network and regimes and use of water bodies should be viewed in the context of the Amu Darya and Syr Darya river basins. Most of the river runoff is regulated, distributed and channeled to meet the needs of irrigated farming.

Uzbekistan's economy largely depends on irrigated agriculture with irrigation being a basic sector of the economy providing over 96% of the gross agricultural product and up to a third of the gross domestic product. Up to 3.5 million able-bodied people, including those working on private farms and land plots, are employed in irrigated farming. More than 60% of the population of Uzbekistan live in rural areas and are engaged in agriculture, which accounts for 60% of foreign currency earnings and 45% of the employment rate.

Mechanical irrigation that pumps water out of the rivers and channels water to the distribution system is practiced on 1.17 million ha. Over 1,500 large and medium pumping stations are used for this purpose. Irrigation canals stretch for 196,000 km, of which central pipelines and farm ditches account for 28,000 km. Drop irrigation is practiced on an area of 4,500 ha. Maintaining the reclamative capacity of irrigated land and preventing salinisation and water-logging largely depend on the efficient operation of the collection and drainage network. Central and inter-farm collection and drainage pipelines stretch 30,000 km, while on-farm networks are 110,000 km in length, and cover 2.8 million ha of irrigated land.



**Figure 2.6**  
Map of Uzbekistan

Source: ADB,  
2010: 47

A total of 60.6 km<sup>3</sup> is diverted for domestic, agricultural and industrial needs, of which 32.9 km<sup>3</sup> is diverted from the major watercourses, 24.0 km<sup>3</sup> from tributaries and small watercourses, 2.8 km<sup>3</sup> are groundwater and 0.8 km<sup>3</sup> are reused drainage water. The breakdown of the uses of diverted water resources is as follows: irrigation accounts for 94.4%, domestic needs for 3.8% and industrial needs for 1.8%. Out of the total water resources diverted for irrigation needs, 58.4% of water is diverted from the Amu Darya basin and 41.6% from the Syr Darya basin.

Cotton is the key agricultural crop with annual production of raw cotton reaching an average of 3.5-4 million tonnes. Uzbekistan is the second largest

producer and second largest exporter of cotton in the world. Cotton accounts for 50% of the country's foreign currency earnings.

The main challenges in the water and sanitation sector are ineffective management, low-quality services, poor health of facilities and underfinancing. In recent years, the government's investment in water supply and sanitation facilities have increased due to, among other factors, foreign investment, which is also used to develop and effectively manage water supply facilities.

Many water supply facilities servicing residential areas are based in basins with limited water reserves. Urban water supply is not the largest water user; however, its competition for water with other sectors, primarily, with agriculture, becomes particularly evident in drought seasons. The water shortage goes hand in hand with pollution and contamination resulting from agricultural and industrial activities in certain areas, and the loss of drinking water due to both leakages and a lack of water conservation practices.

The institutional water management framework is based on the Ministry of agriculture and water management (Minselvodkhoz), which is a national water authority, under which the Department for Water Management functions, with its area-based and other structural divisions. The water management mandate is also attributed to the State Environmental Committee, the State Committee for Geology and Mineral Resources and Administration of Hydrometeorology, all having area-based representation offices. As the Law On Water and Water Use defines, the Minselvodkhoz has the authority to distribute surface water reserves, and the State Committee for Geology has the authority to distribute groundwater. Both the Ministry and the State Committee determine water diversion quotas for all levels of water allocation, which are mandatory for all water users regardless of their departmental affiliation. The Ministry's Department for Water Management performs the water planning, development and allocation duties. At the same time, the Department is responsible for maintenance of water reservoirs, pumping stations for irrigation, central and inter-farm irrigation and drainage networks as well as the monitoring of irrigated land. The hierarchy and territorial organisation of the Department for Water Management adjusted to suit its duties and responsibilities is typical across all Central Asian countries. The system can be described as lacking in the delegation of authority to lower level and limited decentralisation of the water management sector.

The legal framework to guide water relations is based on the Law On Water and Water Use.

Uzbekistan's State Inspectorate for the control and supervision of the technical condition and operational safety of large and particularly important water facilities (Gosvodkhodnadzor) is responsible for the development

of recommendations and governmental resolutions to rehabilitate and upgrade basic irrigation and drainage infrastructure. Based on the findings of an assessment carried out by the Inspectorate, a detailed list of basic and strategic irrigation and drainage facilities (such as large canals, water reservoirs, dams and pumping stations) to be rehabilitated was developed.

The country has consistently implemented a programme that aims to improve the water supply and reclamative capacity of its irrigated land, and to upgrade and renovate central and local canals and collectors.

Uzbekistan assigns great importance to new seasonal storage reservoirs. This has been defined as a short-term priority of its national water strategy to ensure sustainable water management. These reservoirs will be used to conserve water during low-water seasons, which can then be used during the vegetation period. The idea is that the runoff water from all rivers, including the most water-bearing one, will be used entirely for irrigation. Special reservoirs for irrigation needs have been planned for development in the lee of the mountains and in the plains. They will make up for the runoff of the small water bodies located in these areas.

**Environmental situation.** Uzbekistan located in the central part of Central Asia with deserts and semi-deserts accounting for 80% of its territory. Uzbekistan is faces major challenges in terms of water resources, because most of its water reserves come from beyond its borders.

Uzbekistan has adopted the following scale of environmental zones of its territory: 8% of the country's territory lies in ecological disaster zone with 0.1% of the total population affected; 29% of the territory and 12% of the population are in an environmental emergency zone; 37% of the territory and 41% of the population are in an environmental crisis zone; and, finally, 26% of the territory and 47% of the population are in a safe environmental zone. The most deteriorated environmental status is attributed to the Sub-Aral area, which is home to such parts of Uzbekistan as the Republic of Karakalpakstan and Khorezm oblast. The ecological disaster zones and the environmental emergency zones are defined by the extensive pollution of surface and groundwater, a large share of saline and water-logged irrigated land, low-quality soils, a high rate of salinisation of irrigated land and the substandard quality of drinking water.

It is also noteworthy that over the last 20 years hydrological data and rates of sectoral water consumption across Central Asia have become less reliable, which makes it difficult to provide accurate estimates of water reserves in transboundary river basins.

What distinguishes water use at any level is a complex system of facilities to manage and transport river runoff, the treatment of drinking water and contaminated waste water and counteraction of water-related disasters

such as flooding, debris flow, etc. In addition to water facilities and structures, the system includes respective water conservation zones and shelter-belts maintaining the environmental security of water facilities.

The integrated formation of surface and groundwater and the distribution of water within river basins, interdependence of runoff control and diversion and ecological sustainability of river ecosystems has predetermined the transition to watershed management, which now underlies the water legislation of all Central Asian states. For example, Article 34 of Kazakhstan's Water Code provides that national water resources management strategies will be based on the watershed approach. According to Article 40, watershed management agencies shall apply a watershed approach to integrated water resources management of hydrographical basins; develop and implement basin agreements pertaining to rehabilitation and protection of water facilities based on long-term development plans and programmes for respective basins, the finalisation of basin water resources assessments as well as the operating rules for water facilities and hydraulic structures. Article 43 specifies that basin agreements provide for Basin Councils, which are advisory bodies reviewing pressing matters related to water use and conservation and putting forward recommendations to the parties to basin agreements.

Article 5 of the Kyrgyz Water Code also provides for the watershed approach, which entails water resources management within the boundaries of the main hydrographical basin, which covers Lake Issyk Kul and Kyrgyzstan's major rivers. Following a proposal from the National Water Council, the government of the Kyrgyz Republic shall specify the mandate and geographical scope for all basin water administrations and basin councils. These decisions are then made public through the national media. In each main basin, the respective basin water administration and basin council shall be responsible for certain aspects of water resources management.

Article 9 of the Water Code of the Republic of Tajikistan specifies that the national water use and conservation strategies shall be based on a combination of watershed, territorial and administrative-territorial management approaches. Article 8 of the Law of the Republic of Tajikistan "On Water and Water Use" further defines that water management functions shall be carried out by public water authorities per se or delegated to basin (territorial) administrations or other public bodies.

In accordance with the Resolution of the Cabinet of Ministers of the Republic of Uzbekistan no. 320 dated July 21, 2003 "On Improving the Organisational Framework of Water Management", basin authorities were set up to manage irrigation facilities. These consist of authorities managing major canals and authorities managing irrigation facilities.

## 2.2 Major transboundary river basins in Central Asia

Using its physiographic conditions, Central Asia can be subdivided into four large sea and lake basins, which are the Aral Sea basin, Lake Balkhash basin, the north-eastern part of the Caspian Sea, the Ural and Emba Rivers, and the Kara (Karskoe) Sea basin. The surface water reserves of all Central Asian states, including the Kara (Karskoe) and Caspian Sea basins (which cover the eastern and western parts of Kazakhstan) total 235.8 km<sup>3</sup>.

Central Asia is home to over 89,000 rivers and almost 6,000 lakes (see Table 2.1). The drainage density of the mountain areas of Central Asia is 0.617 km/km<sup>2</sup> and 0.02 km/km<sup>2</sup> in the plains.

River basin	River		Lake	
	Grand total	Length >10 km	Grand total	Area >1 km <sup>2</sup>
Amu Darya	40,999	1,787	2,619	129
Syr Darya	29,790	1,907	1,405	65
Talas	3,632	276	467	23
Chu	5,244	491	506	39
Total for CA	89,018	4,979	5,961	321

**Table 2.1**

Rivers and lakes in the major basins of Central Asia

Source: ICARDA, 2009: 66

Regional water resources estimates vary across countries and are based, largely, on old data. There are various estimates of water reserves, which were made by different researchers in 1949, 1955, 1967, 1969 and 1987. Increased impact of human-caused and climatic factors on river runoff and the formation of groundwater as well as new large water facilities put into operation in transboundary river basins dictate the need to undertake an assessment of the water resources in Central Asia.

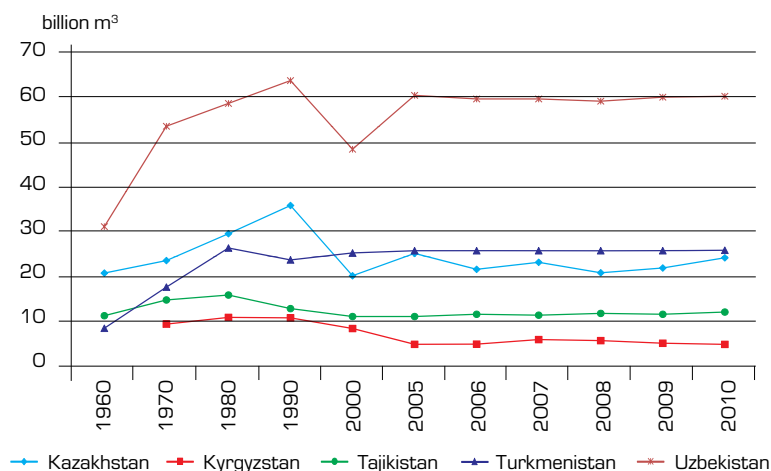
River basin	Multiyear average runoff	90% probability/duration runoff	Usable runoff
1. Aral Sea basin			
Amu Darya basin	79.5	60	65.9
Including Amu Darya River	68.1	52.2	59.9
Syr Darya basin	37.2	26.8	33.2
including Syr Darya River	33.8	24.8	31.3
Endorheic river basin – Chu, Talas, Assy	5.8	4.8	5.1
including Chu River	4	3.4	3.5
Other small watercourses	4.4	3.4	2.4
Total	126.9	95	106

	River basin	Multiyear average runoff	90% probability/ duration runoff	Usable runoff
2.	Balkhash basin			
	Ili Basin	18.1	14.2	11.4
	Karatal, Ak-Suu, Lepsy, Ayaguz and other river basin	6.1	3.7	3.5
	Total	24.2	17.9	14.9
3.	North-eastern part of the Caspian Sea basin			
	Ural basin	10.3	3.2	8.1
	Basin of the Volga-Ural-Emba interfluve	1.8	–	–
	Endorheic rivers of Northern and Central Kazakhstan	2.6	0.3	–
	Total	14.7	3.5	8.1
4.	Kara (Karskoe) Sea basin			
	Irtysch basin (within borders of Kazakhstan)	28.8	25.6	27
	Tobol basin	1.4	0.5	0.7
	Total	30.2	26.1	27.7
	Grand total	196	142.3	157.3

**Table 2.2**  
Surface water reserves in Central Asia

Source: Volynov et al., 1980: 17

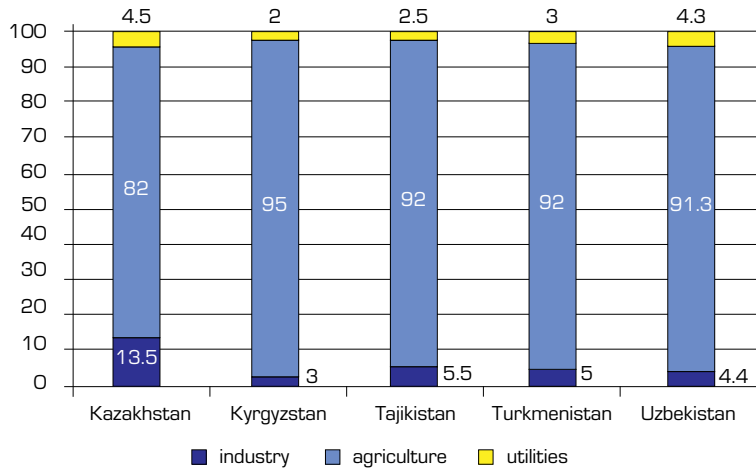
Surface runoff of Central Asian rivers varies greatly depending on season and year. Frequent droughts occurring in some parts of the region contribute to runoff irregularity. All Central Asian countries use over 82% of their water reserves for irrigation purposes. Water use for domestic and industrial needs accounts for 2-4.5% and 2-13.5% of total water consumption,



**Figure 2.7**  
Water diverted from natural water sources in Central Asia

Source: CIS ISC

respectively. Countries largely dependent on transboundary rivers such as Turkmenistan and Uzbekistan divert the highest shares of water: 94% and 77%, respectively.



**Figure 2.8**  
Water use  
in Central Asia (%)

Source: CIS ISC

Groundwater reserves are distributed unequally with vast territories having insignificant usable water reserves and large areas being arid. Western, some central and northern parts of Kazakhstan, and central and western parts of Turkmenistan have extremely limited reserves of usable fresh ground water.



**Figure 2.9**  
Transboundary  
surface water  
in Central Asia

Source: ADB,  
2010: 70

The diversity of transboundary rivers is a geopolitical characteristic of Central Asia. Due to natural and climate conditions, surface river runoff fluctuates greatly and is affected by low-water periods, which return frequently.

### **2.3 Water resources of the Aral Sea basin (based on integrated water resources management and conservation plans)**

The Aral Sea basin is a closed drainage basin covering a significant area of Central Asia as well as northern provinces of Afghanistan and Iran within the Tejen and Atrek river basins. It is a large area naturally and historically located in Eurasia with diverse environmental conditions influenced by its continental geographical position and orographic characteristics.

The Aral Sea has been the subject of many studies. The first surveys around the Aral Sea were initiated by L. Bekovich-Cherkasskiy during his 1715-1716 expeditions commissioned by Peter I. The Aral Sea became a specific research target as of mid-eighteenth century due to closer ties between Russia, Kazakhstan and Central Asia. In 1740-1741 an expedition was sent to the Aral Sea to conduct a reconnaissance survey and identify a site for a future town at the mouth of the Syr Darya. The instrumental survey resulted in a landscape map, which covered a part of the Aral Sea, the delta of the Syr Darya, and Khiva region. It is one of the oldest Russian maps of the region and indicates urban communities that were later destroyed and riverbeds that later shifted or dried up (USSR, 1990: 10-12).

In the 1820s, the Aral Sea region was a subject of a study by E.A. Eversman who described physical, geographical and geological characteristics of the Sub-Aral region and put forward the theory that the Aral Sea was drying up.

In the 1840s, the expedition of G.I. Danilevskiy and F.I. Baziner was based in Khiva. Their report entitled "A Description of Khiva" published in 1851 gave details about the climate, relief and geography of the Ustyurt Plateau and the Aral Sea region. A large-scale map of the Aral Sea and Khiva developed by F.I. Baziner was included in A. Gumboldt's book, "Central Asia".

In 1851 Ya.V. Khanykov, a geographer and cartographer, published a map of the Aral Sea and Khiva together with an explanatory note describing the history of the Aral Sea.

The first expedition that directly targeted the Aral Sea basin was organised by A.I. Butakov in 1848-1849. The expedition conducted a general reconnaissance survey of the sea, the coastline and the island of Barsakelmes, described the eastern shore of the sea and the islands, specified the geographic coordinates, measured the depth and studied the currents. A group of islands presently known as Vozrozhdeniye and Komsomolskiy was discovered. The expedition also collected data on the physical geography and

geology of the shores. Butakov's survey of the Aral Sea and downstream of the Syr Darya played an important role in the development of those areas, in particular in navigation on the sea and the river. In 1850, soon after the expedition, the first accurate map of the entire Aral Sea was drawn based on the survey's materials. The expedition made an important conclusion about how the coastline was formed, which was the initial step in Russian studies of marine coasts. However, the first reports published only brief information about the findings, while the full report was published 100 years later.

In 1857-1858, N.A. Severtsov and I.G. Borschov undertook a physiographic survey of the northern and eastern shores of the Aral Sea and, in addition to other things, studied the signs of sea shrinkage. The morphometric characteristics of the Aral Sea were first specified by I.A. Strelbitskiy in 1874 and 1889 based on the maps of Asian Russia.

In 1873 Khiva joined Russia, which incentivised research in the Sub-Aral region. In 1874, two expeditions were based in the region: the Aral-Caspian expedition commissioned by the Petersburg society of natural philosophers and the Amu Darya expedition sent by the Russian geographical society. The first expedition surveyed the west and north coasts, while the Amu Darya expedition was stationed on the south and south-east coasts of the Aral Sea. In 1874 they made a precise record of the sea level and put a benchmark on the north-west coast of the Aral Sea, thus laying a sound foundation for sea level control points in the future.

The primary findings of the Aral Sea water analysis were initially published in 1870. The findings of the other five tests carried out between then and 1900 were published later.

In 1897 in Tashkent, the Turkestan division of the Russian geographical society was set up, which made a significant contribution to the study of the Aral Sea. A significant contributor to the society was L.S. Berg who, between 1900 and 1903, organised a comprehensive geographical and hydrological survey of the sea and the adjacent territories and recorded the sea level.

In 1900 Berg organised the first gauge sea level observations in the north coast's Bolshoi Sarychaganak inharbour. In 1904 a tide level gauge was installed in the same area, which worked a few months of 1904 and 1905. Berg reproduced the sea level fluctuations for the 1780-1903 period using indirect data, while the period of 1874 and 1911 was studied by V.P. Lvov. The findings of Berg's studies made it to a 1908 monograph entitled "The Aral Sea", which offered an in-depth description of the climate and physiogeographic characteristics as well as the specifics of the regimen of the sea such as sea level fluctuations, water temperature, color, clarity and salinity. It was the first work to describe the seiche of the Aral Sea and the coast morphology and development, assess the influence of the sea regimen and it

also identified the link between the sea level and the climate. Berg's paleoclimate surveys allowed him to disaffirm the then-popular view of the progressive drying of Central Asia. He made important conclusions about the historical sea level fluctuations that influenced the theory of hydrometeorological processes.

Tide level gauge observations became systematic in 1911 and were based on the Aral Sea gauging station founded around Aralsk in 1884.

The Sub-Aral region and the Aral Sea were further developed following the opening of the Tashkent railway in 1905. The new government commissioned a number of surveys between 1906 and 1915 to contribute to the development of the region. In 1914 the Turkestan division of the Russian geographical society conducted a leveling survey that recorded a new elevation in the sea level.

From 1920, hydrochemical, hydrobiological and ichthyological surveys of the Aral Sea were expanded. In the mid-1930s and the early 1940s a network of gauging stations was developed on the Aral Sea resulting in regular observations of the sea level, water temperature, salinity, density, rise and fall as well as ice phenomena. Surveys were underway to study the water-salt balance, hydrometeorological and hydrochemical regimes of the sea and the reproductive biology of fish. Measures were taken to help fish from other basins adjust to the new conditions. The Amu Darya and Syr Darya delta surveys were also expanded to study coastal development patterns as well as soil and plant cover.

Beginning in 1941, the findings of coastal observations and deep ocean works were summarised in marine yearbooks and monthly publications as well as in publications by the USSR Water Cadastre.

After the WWII, hydrometeorological, hydrochemical and hydrobiological surveys were expanded in the Amu Darya and Syr Darya basins in connection with the construction of the Main Turkmen (Karakum) Canal and the government's decision to develop irrigation.

Extensive hydrographical fieldworks were undertaken in 1958-1960 resulting in the renewed Aral Sea sailing directions. In the early 1960s a number of new gauging stations were founded on the Aral Sea complemented with a standard network of secular open sea hydrographical stations to conduct seasonal surveys of the basin and a standard set of hydrometeorological and hydrochemical observations. Aerial ice reconnaissance surveys were also regular during winter.

Today many researchers are interested in the shrinking of the Aral Sea, which began in the 1960s. The findings of the hydrometeorological and hydrochemical surveys were analysed in the 1970s and early 1980s.

The Aral Sea basin includes in the basins of the Amu Darya and Syr Darya, two continental rivers located in the northern and western parts of the Sub-Aral region. In endorheic zones a water district includes, as a rule, an entire river basin or several basins of smaller rivers. The Amu Darya basin is the largest in terms of area and water availability. It is called the Amu Darya from the point where the Panj joins with the Vakhsh and has a length of 1,440 (2,500) km. The Syr Darya is known to start from the point where the Naryn joins with the Kara Darya. At a length of 2,140 (2,790) km, it is the longest river in the Aral Sea basin. The Amu Darya basin has almost two times more water than the Syr Darya basin.

The Amu Darya and the Syr Darya flow into the Aral Sea, which formerly had the fourth largest water surface area after the Caspian Sea, Lake Superior in North America and Lake Victoria in Africa. With a sea level of 53 m, the absolute area of the sea was around 68,300 km<sup>2</sup>, of which water surface area accounted for 66,100 km<sup>2</sup>, with a volume of 1,064 km<sup>3</sup>, and an average depth of 16.1 m. The sea extended for a maximum of 432 km in length and 292 km in width (average width at 156 km). The Aral Sea once had over 1,100 islands with a total area of about 2,235 km<sup>2</sup>, the largest islands being Kokaral, Barsakelmes and Vozrozhdeniye. The name of the sea refers to the myriad of islands that once were dotting its waters – “aral” means island. The Aral Sea was formerly navigated, from Aralsk, a seaport in the Syr Darya delta, to Moynaq, a seaport in the Amu Darya delta. The region once had a prosperous fishing industry accounting for an abundant catch of valuable commercial species (up to 70,000 tonnes annually) (UNEP, 2011).

The Aral Sea basin covers the whole territory of Tajikistan, Uzbekistan, a major part of Turkmenistan, four provinces of Kyrgyzstan, the southern part of Kazakhstan and the northern part of Afghanistan and Iran with a total area of 1,549,000 km<sup>2</sup>. 35% of Kazakhstan's irrigated lands and up to 40% of Kyrgyzstan's irrigated lands lie within the Aral Sea basin.

The basin's central position within a vast continent reflects the general characteristics of its climate. Temperatures are generally high, with long hot summers (average July temperatures range from +26 to +32°C). Cold air masses reaching the region in the winter months lower overall temperature level. The average January temperature records are between -10 and -15°C in northern deserts and above 0°C in the south. The continental climate shows itself in the high fluctuations in annual weather elements and significant daily weather variations, which are most common in the region's plains.

The annual precipitation of about 100 mm is brought over with humid air streams formed over the Atlantic Ocean. This makes climate very dry. The precipitation-evaporation ratio is 0.1-0.2 in northern deserts and less than 0.1 in southern deserts.

The dry continental climate and relief influence the formation and regime of surface water, causing extremely unequal distribution of watercourses throughout the Aral Sea basin. The region's mountain areas have numerous watercourses and feed runoff. In contrast, the plains have fewer watercourses with a density of 0.002 km/km<sup>2</sup> versus 0.14 km/km<sup>2</sup> for the overall CIS area.

Water resources of the Aral Sea basin are intensively used for different purposes. The water diversion rate was the highest during 1960-1990, which later became one of the main factors contributing to the shrinking of the sea. It is worth reiterating that even before the water was intensively diverted to irrigate new agricultural lands, the water balance of some basins had already indicated limited water resources. For example, as early as in the beginning of the indicated period (1960), some tributaries did not reach the Syr Darya, because they had been exhausted for irrigation purposes. As described by V. Schulz (1965), the Syr Darya basin is a complex interweaving of natural and artificial waterways-rivers, canals, and water collectors; the total length of the canals and collectors is much greater than that of the natural rivers. Most of the Syr Darya tributaries flow from the mountainous regions that ring the valley. The right tributaries in this region are the Kasansai, Gavasai and Chadaksai; and the left tributaries are the Isfairamsai, the Shakhimardan, the Sokh, the Isfar and the Khodzhabakirgan. Almost none of the tributaries actually contribute water to the Syr Darya, since they are used for irrigation or are lost in broad alluvial fans.

Approximately 700 canals lead from the rivers flowing into the valley, and approximately 50 canals lead from the Syr Darya within the confines of the valley. The largest canals include the Grand Ferghana (supplemented from the Kara Darya), Grand Andijan, and Northern Ferghana canals, all leading from the Naryn; the Andizhansai, Shaarikhansai, and Savai canals, all leading from the Kara Darya; and the Akhunbabaev Canal, which leads from the Syr Darya.

The mountain rivers and the Syr Darya receive waters from more than 100 collectors and drains, including 43 that empty into the Kara Darya and 45 that empty into the Syr Darya. The largest collectors are the Sarysu, Karagugon, and the Severo-Vagdad. From the Ferghana Valley, the Syr Darya cuts through the Farkhad Mountains, forming the Begovat Rapids. It then turns to the northwest and acquires a broad, sometimes swampy floodplain form 10 to 15 km wide as it intersects the Tashkent-Golodnaya Steppe Depression. In its middle course – from the point where it leaves the Ferghana Valley to the point where it enters the Chardara Reservoir – the Syr Darya receives waters from the Akhangaran, Chirchik, and Keles rivers. The Yuzhnaya Golodnaya Steppe Canal begins at the Farkhad Hydropower Plant and flows northward. The lower Syr Darya flows

through the eastern outskirts of the Kyzylkum Desert. Here the riverbed is higher than the surrounding land, and it follows a meandering and shifting course. Floods are frequent. The final tributary is the Arys, which enters from the right; the small rivers flowing from the Karatau Mountains do not reach the Syr Darya. Runoff forms in the mountain section of the Syr Darya's basin. The river is fed chiefly by snow and to a lesser degree by glaciers and rain. High water is in spring and summer, from March or April through August or September. In the plains of the river basin, high water occurs with less regularity, and the quantity of water diminishes, principally because the waters are used for irrigation. The perennial mean flow rate of the Naryn at the kishlak of Uch-Kurgan is  $434 \text{ m}^3/\text{s}$ , and that of the Kara Darya near the settlement of Kampyravat is  $122 \text{ m}^3/\text{s}$ . Below the confluence of the two rivers, the rate is  $492 \text{ m}^3/\text{s}$ ,  $566 \text{ m}^3/\text{c}$  at the exit from the Ferghana Valley,  $703 \text{ m}^3/\text{c}$  below the influx of the Chirik River, and  $446 \text{ m}^3/\text{s}$  near the city of Kazalinsk. The total mean annual flow of the rivers is  $37.8 \text{ km}^3$  at the point where they leave the mountains and  $14.1 \text{ km}^3$  near Kazalinsk; that is, in the region where the water is diverted and distributed, the flow is reduced by  $23.7 \text{ km}^3$  per year, which constitutes 63% of the water flowing from the mountains (Schulz, 1965). Thus, before it started to shrink, the Aral Sea received  $14.1 \text{ km}^3$  of water from the Syr Darya and almost the same, and even more, from the Amu Darya, which ensured the environmental sustainability of the sea and the whole basin.



**Figure 2.10**  
Water resources of  
the Aral Sea basin

Source: UNEP,  
2011: 15

All contemporary estimates of the water resources of the Aral Sea basin are based on the data and studies made in the 1960-70s by various Soviet engineering companies, in particular, Sredazgiprovodkhlopok, the Gidroproekt office in Central Asia (based in Tashkent) and others, as part of the so-called integrated river basin water resources management plans.

It is commonly held that an Integrated water management and conservation plan is a concept paper specifying a principal set of long-term water and other measures to meet residential and sectoral water demand. It uses integrated data of research and design studies on the current status and future development of integrated use and conservation of water resources and control of adverse water effects linked with long-term development of all sectors of the national and regional economy.

Given that the earlier assessments of water resources content made in the framework of elaboration of integrated plans for water management and conservation in the Aral Sea basin remain the only source of data on the basin's water content and were used as the justification for decision making regarding transnational water use, it seems reasonable to briefly describe its findings.

The first plan of the integrated water management and conservation of the Syr Darya River Basin was prepared in 1970 by Sredazgiprovodkhlopok Institute (Tashkent) and reviewed by the State expert commission of the USSR State Planning Committee on February 7, 1973 (Resolution no. 2). The resolution specified the irrigation capacity of the Syr Darya at 3,160,000 ha, including 1,770,000 ha in Uzbek SSR, 420,000 ha in Kyrgyz SSR, 220,000 ha in Tajik SSR, and 750,000 ha in Kazakh SSR. Water diversion was assumed to reach 55.6 km<sup>3</sup>, including 13.5 km<sup>3</sup> of return water runoff.



**Figure 2.11**  
The Syr Darya River Basin

Source: UNECE, 2011b: 115

Based on the above resolution and the assignment of the USSR Minvodkhoz of January 30, 1976, the integrated water management and conservation plan for the Syr Darya Basin was updated in 1976-1978. The figure for total basin water reserves was adjusted and assumed to be 40.9 km<sup>3</sup> in an average water year, of which registered surface runoff accounted for 36.7 km<sup>3</sup>, unregistered surface runoff for 0.75 km<sup>3</sup>, groundwater for 2.18 km<sup>3</sup>, and precipitation infiltration for 1.30 km<sup>3</sup> – all according to multiyear data covering the period from 1910 to 1976. The Syr Darya basin water reserves were assumed to reach 34.9 km<sup>3</sup> in a year with 95% of assured runoff and 28.7 km<sup>3</sup> in a year with 75% of assured runoff.

The updated plan was reviewed by the expert subcommittee of the State expert committee of the USSR State Planning Committee, which released a respective resolution dated April 12, 1982. This was used as a basis for the State expert committee (SEC) of the USSR State Planning Committee to produce Resolution no. 11 of May 5, 1982: "A Review of the Updated Plan for the Integrated" Management and Conservation of Water Resources of the Syr Darya Basin. In doing so, the SEC of the USSR State Planning Committee approved the resolution of the expert subcommittee of April 12, 1982 on the updated plan of integrated management and conservation of basin water resources, including the comments and recommendations the subcommittee put forward, and advised the USSR Minvodkhoz to:

- integrate the data contained in the Syr Darya integrated water management and conservation plan (including the comments and recommendations of the expert subcommittee dated April 12, 1982) in the new sectoral plan for development of reclamation and water sector up to the year 2000;
- urgently develop and approve a memo specifying the limits of water resources by sources, water zones and parts of the basin included in territories of the Soviet republics. It was also advised to use the water apportioning approach specified in the resolution of the expert subcommittee and take into account the need to assure multiyear average inflow into the Chardara reservoir at 12 km<sup>3</sup> per year out of 37.4 km<sup>3</sup> of regulated surface runoff with an accepted decrease to 10 km<sup>3</sup> in low-water years with 90% of assured runoff;
- ensure the specified inflow by releasing water from the upstream reservoirs, if need be, which entailed a storage of water at the gate of Chardara that was both of assured quantity and assured quality with salinity up to 1 g/l;
- engage with the stakeholding ministries and institutions to develop basic rules for the use of water resources of the reservoirs making up the

Naryn-Syr Darya cascade in order to ensure sound water management in the Syr Darya river basin;

- integrate the present resolution and the resolution of the expert subcommittee of April 12, 1982 as well as the water limits specified by the USSR Minvodkhoz into the new area-based productive forces development and distribution plans and integrated water management and conservation plans. (GEF, 2003).

In order to further develop the resolution, as well as to integrate the comments of the expert subcommittee of the State expert committee of the USSR State Planning Committee into the updated plan, the Sredazgiprovodkhlodok engineering institute developed the "Update of the Integrated" Water Management and Conservation Plan for the Syr Darya River Basin (memo) (1983); "Syr Darya River Basin. Executive report" (1985); "Plan for Water Management Activities in the Syr Darya Basin up to the year 2000" (until complete exhaustion of own water resources); "Executive summary" (1987).

However, the above concept papers failed to go through the necessary approval stages both at the USSR and republican levels, and, as a result, lost their status as guidelines. After the fall of the USSR, the Resolution of the expert subcommittee of the State expert committee of the USSR State Planning Committee dated April 12, 1982 and Resolution no. 11 of the State expert committee of the USSR State Planning Committee dated May 5, 1982 were consulted to decide on transnational water use issues. That resolution specified an increased irrigated capacity of the Syr Darya based on the expectation that the irrigation equipment and practices be improved, irrigation facilities upgraded and well-maintained, and efficient water resources management ensured in the basin. The resolution advised keeping the irrigated area under 3,520,000 ha when the Syr Darya fell short of its own resources by 1987-1988 and irrigation quota decreased by 10% by 1990.

As stated above, as early as 1975 the water intake in the Syr Darya basin reached 39.4 km<sup>3</sup> exceeding the available and accessible surface runoff (36.7 km<sup>3</sup>), with the area of irrigated land approaching the 2,660,000 ha mark. At the same time, the Plan of 1970 expected to increase irrigated land up to 3,160,000 ha, while the memo to the 1978 Plan up to 3,400,000 ha, and the Resolution of the SEC of the USSR State Planning Committee (1982) up to 3,520,000 ha. Thus, the top-bottom directive planned to further expand irrigated lands, with the irrigation capacity of the Syr Darya river remaining unchanged. The scheduled water management and reclamative works on irrigated land, which were supposed to release water resources for new lands, never took place. Therefore, one should assume that by 1970-1975 when the irrigation capacity of the Syr Darya river was completely exhausted, further environmentally unsubstantiated expansion of irrigated land in the

river basin intensified the regional water management situation, which later turned into the largest environmental crisis of the 20<sup>th</sup> century.

A similar situation was observed in the Amu Darya basin. In 1950-1954 the Sredazgiprovodkhopok institute developed the first “General Plan for Water and Land Resources Management in the Amu Darya River Basin”. Then in 1967-1971, the Central Asian office of Hidroproekt based in Tashkent developed the “Master Plan for the Integrated Water Resources Management of the Amu Darya River”. Its first draft was reviewed and approved by the SEC of the USSR State Planning Committee (1969), and its second draft approved by the technical and scientific council of the USSR Minvodkhoz (1972). Until 1984, this plan was used as guidelines specifying the overall water management context for economic development in the Amu Darya river basin up to the 1985 level. The document specified the division of water resources between the Soviet republics and defined the potential limits for the development of irrigated agriculture using the river’s own runoff with seasonal storage reservoirs. The Plan fixed the river’s irrigation capacity for the year 1985 at 3.85 million ha and acceptable water diversion at 59 km<sup>3</sup>.



**Figure 2.12**  
The Amu Darya River Basin

Source: UNECE, 2011: 109

The Master Plan tentatively limited the potential expansion of irrigated land at 5.2 million ha – a long-term projection taking into account exhaustion of the Amu Darya’s own water resources (within the USSR boundaries). In 1987 the USSR Minvodkhoz approved the “Updated Plan for the Integrated Management and Conservation of Water Resources of the Amu Darya

River Basin” produced by Sredazgiprovodkhlpok, which has been used to decide on transnational water apportioning issues in the Amu Darya basin to date. According to the Plan, the breakdown of surface runoff entitlement by country was as follows: 0.6% for Kyrgyzstan, 15.4% for Tajikistan, 35.8% for Turkmenistan and 48.2% for Uzbekistan (as% of estimated runoff along the Amu Darya).

The quota system is still used, and in accordance with this water accumulated at the gate of the Kerki gauging station is equally divided between Turkmenistan and Uzbekistan, including the water diverted to the Kayrakum canal. The division was reflected in the agreement both parties signed in Charjew (Turkmenabad) in 1996.

The total multiyear water reserves of the Amu Darya river basin was estimated at 78.4 km<sup>3</sup>, of which registered surface runoff accounted for 77.7 km<sup>3</sup>, unregistered surface runoff for 0.24 km<sup>3</sup> and groundwater for 0.447 km<sup>3</sup>. As of January 1, 1981, irrigated land in the river basin was registered at 3,233,400 ha, including 1,838,800 ha in Uzbek SSR, 417,800 ha in Tajik SSR, 16,300 ha in Kyrgyz SSR, and 960,500 ha in Turkmen SSR.

The abovementioned plans were developed separately for the Syr Darya and Amu Darya basins. There was no Plan covering the entire Aral Sea basin, despite repeated attempts at agreeing one. In 1973 Sredazgiprovodkhlpok (Tashkent) drafted a Plan for Integrated Water Resources Management of the Aral Sea Basin, which, however, failed to go through the necessary approval stages. As a result, it was not used as a baseline document for the project.

The Syr Darya river basin extends over 45 million ha, of which agricultural land accounts for 33 million ha, of which in 1975 2.66 million ha was irrigated; 1.16 million ha under cotton; 376,000 ha under grain, including 102,000 ha of rice fields; 157,000 ha under industrial and vegetable crops, except for cotton, melons and potatoes; 200,000 ha under perennial plantations; and 130,000 ha under other crops. The crop structure demonstrates that cotton production was the leading sector of agriculture. Cotton was grown primarily in the central part of the Syr Darya basin. Grain cultivation and cattle breeding were focused in upstream areas, while rice growing and cattle breeding in downstream areas. The unused land suitable for irrigated was estimated at 10.7 million ha. In 1975 39.4 km<sup>3</sup> was diverted from the basin for irrigation needs, and a further 20.3 km<sup>3</sup> for water consumption. This means that by that time water intake was already by far exceeding the surface runoff of the Syr Darya river basin. At the same time, the memo to the 1970 plan reconsidered the Syr Darya’s irrigation capacity and estimated it at 3.4 million ha, which was expected to be reached between 1985 and 1990.

In 1989 Soyuzvodproekt and Soyuzgiprovdkhov (Moscow) developed a new Plan for the Integrated Management and Conservation of Water and Land Resources of the Aral Sea Basin, which was based on the above concept documents and respective memos.

The new Plan also looked at the issues related to irrigated lands and reclamative capacity thereof. As of January 1, 1986, the total land area of the Aral Sea basin on the Soviet territory was 1.57 million km<sup>2</sup>; agricultural land was estimated at 102.9 million ha, of which cultivated land accounted for 7.9 million ha, hay fields for 0.6 million ha, rangeland for 93.7 million ha, fallow land for 0.9 million ha, and perennial plantations for 0.5 million ha. Rangeland accounted for the largest share of agricultural land ranging from 96.8% in Turkmenistan to 73% in Tajikistan. Cultivated land – around 8% of the agricultural land – was the most valuable land, particularly, irrigated, ploughed farmland, which was used for most of the agricultural produce.

Over 1965-1985, irrigated land increased by 2.5 million ha, with total irrigated land registered at about 6.9 million ha as of January 1, 1986. Uzbekistan accounted for 1.3 million ha of new irrigated lands, and Turkmenistan for 0.65 million ha. Cultivated land accounted for the largest share of irrigated land, about 90%: 51.1% of this was under cotton, 26.8% under forage grass, 15.9% under grain, and 5.1% with potatoes, vegetables and melons.

The key provisions of the new Plan of 1989 were sent for approval to the respective management authorities of the Soviet republics. The Plan estimated water resources of the Aral Sea basin at 115.9 km<sup>3</sup>, of which Amu Darya accounted for 78 km<sup>3</sup>, including 2 km<sup>3</sup> worth runoff from the continental rivers of northern Afghanistan, and 37.9 km<sup>3</sup> from Syr Darya (see Table 2.3, 2.4).

The key provisions of the Plan specified the range of estimates made by the authorised division of the USSR Academy of Sciences, the USSR State Committee of Hydrometeorology (Goskomgidromet), the USSR Ministry of Energy and the USSR Ministry of Water and Reclamation (Minvodkhov) at different points in time. These estimates were based on runoff observation series of different length and different reporting periods for human-caused factors distorting the natural runoff. The Aral Sea Plan was assumed to continue to adjust the figures indicating the basin water resources by engaging a variety of leading organisations. However, even then it was emphasised that the adjustments could not significantly influence the initial data, as more accurate estimates of water resources of the Amu Darya and Syr Darya basins could only be made based on observations over one hydrological year. Furthermore, in addition to reliable assessment of the human-induced factors, the length of runoff observations has a notable effect on multiyear water resources estimates.

No	River	Point	Annual flow (km <sup>3</sup> )	
			Estimated range	Accepted estimation
Rivers draining into the Aral Sea				
1.	Panj	Nijniy Panj	33.1–35.4	33.4
2.	Vakhsh	Tigrovaya balka	20–22.9	20.2
3.	Kunduz		3.4–3.7	3.5
4.	Kafirnigan	Tartki	5.4–5.7	5.6
5.	Syrkhan Darya	Manguzar	3.5–3.9	3.7
6.	Sherabad Darya		0.2	0.2
	Total: Amu Darya	Kerki	65.6–71.8	66.6
Continental rivers receiving water from the Amu Darya				
1.	Zeravshan	Karakul	8.2–6.2	5.3
2.	Kashka Darya	Bolnichny	1.3–1.5	1.3
3.	Murghab	Takhta–Bazar	1.6–1.7	1.6
4.	Tejen	Pulikhatum	1.0–1.5	1.2
	Total:		9.0–10.9	9.4
5.	Continental rivers of northern Afghanistan		1.9–2	2
	Grand total:		76.7–84.7	78

**Table 2.3**  
Natural water resources of the Amu Darya Basin, multiyear annual average

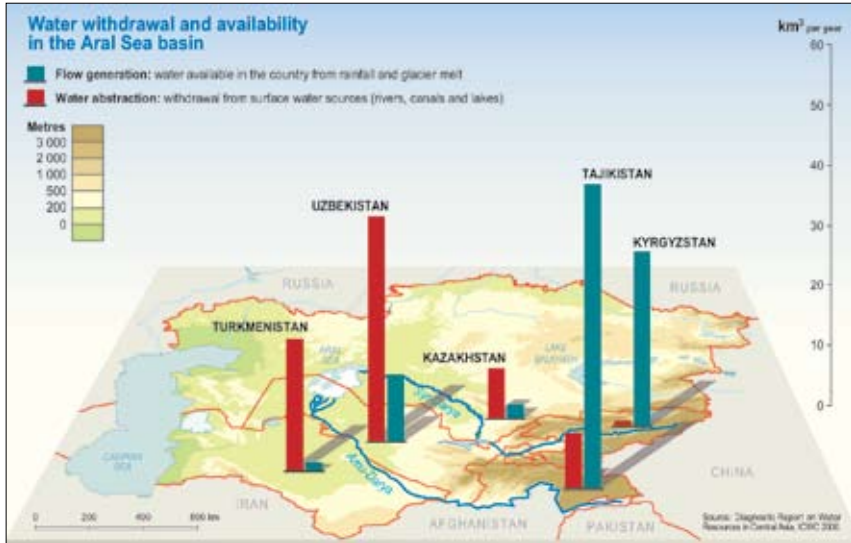
Source: Soyuzgiprovodkhoz, 1989

No	Course	Annual flow (km <sup>3</sup> )	
		Estimated range	Accepted estimation
1.	Upper course – before start of the Syr Darya	25.9–26.8	26
2.	Middle course – up to the Chardara Reservoir	8.9–10.4	9.5
	Total:	34.8–37.2	35.5
3.	Lower course – between the Chardara Reservoir and the Aral Sea	2.1–2.6	2.4
	Grand total: Syr Darya	36.9–39.8	37.9

**Table 2.4**  
Natural water resources of the Syr Darya Basin (multiyear annual average)

Source: Soyuzgiprovodkhoz, 1989

It should be noted that the Plan provided a quite objective and critical discussion of the reliability and representativeness of the threshold hydrological data used to assess water resources of the Syr Darya and Amu Darya basins as well as the Aral Sea basin as a whole. These remarks are still valid today, or may have become even more so in the context of a lack of a universal methodology to assess the water resources in Central Asia. The human-induced factors make it difficult to assess the natural runoff (water



**Figure 2.13**  
Water withdrawal  
and availability in the  
Aral Sea basin

Source: UNEP,  
2005: 21

resources) of the Amu Darya and Syr Darya basins with the indicated length of hydrological observation. Irrigational intake and discharge as well as reservoir-regulated runoff have altered the natural runoff. Data obtained through hydrological observation over water use fails to give an accurate estimate of natural water resources. This accounts for the disparities between the estimated runoff flowing naturally from its source and the runoff registered by the gauging stations located at the points where rivers left mountain areas.

Due to unreliable data on water intakes from the rivers, reservoirs and discharge of return and waste water into water bodies, the estimates of natural water resources of the Amu Darya and Syr Darya basins made by different organisations and individual researchers vary. The disparities in estimated natural water resources are attributed to, chiefly, incomplete and unreliable estimates of water used for irrigation and collector-drainage water discharge. Estimates relying on indirect data made using different methodology will clearly vary. Therefore, in order to accurately estimate natural water use, the runoff registered at gauging stations should be adjusted to take into account any reliable data on water intake and discharge as well as the water used to fill and empty water reservoirs.

The new Plan notes that the reviewed water cycles are broken down into high and low flow phases, around which low-water and high-water years as well as extremely high and extremely low-water years are grouped. At the same time, it is noted that the full cycle of water years can only be established after 40-50 year-long observations. This is explained by the fact that river

runoff of the Aral Sea basin is formed in different physical and geographical conditions.

The new Plan registers total multiyear surface runoff at 113.9 km<sup>3</sup>, of which the Amu Darya and Syr Darya account for 76 and 37.9 km<sup>3</sup> respectively (without accounting for 2 km<sup>3</sup> worth runoff of Afghan rivers not connected with the Amu Darya basin hydrologically or economically but included in the basin only due to their location in the catchment area). In addition, between 4.3 and 5.5 km<sup>3</sup> of water can be annually taken from groundwater reserves without affecting surface runoff (between 1.3 to 2 km<sup>3</sup> in the Amu Darya basin, and between 3 and 3.5 km<sup>3</sup> in the Syr Darya basin) with the first figure reflecting the present status, the second the forecast for 2005-2010. Thus, the Plan estimated the total natural multiyear water resources of the Aral Sea basin under the present conditions at 118.2 km<sup>3</sup>, including groundwater reserves, and 119.4 km<sup>3</sup> over 2005-2010. The figure indicates a multiyear average that can be used annually in the Aral Sea basin both for socio-economic and sanitary-environmental needs, including the Aral Sea itself. *Table 2.5* shows the surface runoff resources in different water years and assured water resources from reservoirs in the present (at the time) and in complete river control conditions.

River	Surface runoff in different water years			Assured surface water runoff in a year with 95% of assured runoff	
	Multiyear average (50%)	75%	90%	At the time of development of the plan	including the potential capacity of the Roghun HPP
Amu Darya	76*	69.1	61.3	62.1	68.8
Syr Darya	37.9	31.8	27.9	35.3	35.3
Aral Sea basin, grand total	113.9	100.9**	89.2**	97.4	104.1

The figures indicating annual and seasonal runoff of the Amu Darya and Syr Darya river basins vary over years (years can be easily grouped according to dryness/water content). Of special interest is the water year cycle between 1951 and 1986, which is the period when the Aral Sea was shrinking. The Syr Darya and Amu Darya runoff for the period was quite stable over different years. The period included three high-water and two low-water phases. The first high-water phase covered nine years between 1952 and 1960; the second phase covered the seven years between 1967 and 1973; the third phase covered the three years between 1979 and 1981. The first low-water phase was between 1961 and 1966 covering a period of six years, second between 1974 and 1978 (five years), and third between 1982 and 1984 (three years). The annual and seasonal runoff varied greatly. For example, the annual runoff in the Amu Darya basin was about 110 km<sup>3</sup> in the high-water

**Table 2.5**  
Surface water resources in the Aral Sea basin (km<sup>3</sup>)

Source: Soyuzgiprovodkhoz, 1989.

Note: \* Excluding 2 km<sup>3</sup> worth runoff of Afghan rivers not connected with the USSR hydrologically or economically  
\*\* – as per specified indicators from restored hydrological observation series

year 1969 versus 65 km<sup>3</sup> in the low-water year 1974. The figures in the Syr Darya basin were 70 km<sup>3</sup> in the high-water year 1969 versus 20 km<sup>3</sup> in the low-water year 1983. The fluctuation range for annual runoff over the reviewed period was 45 km<sup>3</sup> for the Amu Darya basin versus 50 km<sup>3</sup> for the Syr Darya basin. The deviation from multiyear average runoff ranges between +34 and -11 km<sup>3</sup> and between +32 and -18 km<sup>3</sup> respectively. It is clear that based on the multiyear average runoff a shortage of water resources will be registered in low-water years. Therefore, water consumption quotas for different sectors and geographical areas are based on assured, rather than multiyear, runoff. Assured water consumption is ensured by regulating both intra-annual (seasonal) and multiyear runoff.

The estimates of the regionally available groundwater reserves that can be used without affecting surface runoff in the Syr Darya and Amu Darya basins are shown in *Table 2.6*.

**Table 2.6**

Groundwater resources not affecting surface runoff (km<sup>3</sup>)

Source: Soyuzgiprovodkhoz, 1989

Basin	Present	1990	1995	2000	2005-2010
Amu Darya	1.3	1.4	1.5	1.8	2
Syr Darya	3	3	3	3	3.5
Total:	4.3	4.4	4.5	4.8	5.5

Glaciers make an important contribution to surface and groundwater in Central Asia. The ice-covered area in the Amu Darya and Syr Darya basins is 7,500 and 2,600 km<sup>2</sup> respectively. Glaciers are on average 200 m thick with water storage capacity estimated at 700-1,000 km<sup>3</sup>. Multiyear average glacier-derived runoff is estimated at 2.2-2.3 km<sup>3</sup> in the Syr Darya basin and at 9.2-10.1 km<sup>3</sup> in the Amu Darya basin. Glacier runoff accounts for an average of 6% of average runoff of the Syr Darya and 15% of the average runoff of the Amu Darya with the figure rising in low-water years and falling in high-water years.

Based on a number of studies, the Plan pioneered an idea about the potential influence of global climate change on Central Asian water resources. It was hypothesized that a growing atmospheric concentration of CO<sub>2</sub> might lead to global warming with a highly likely effect of climate change on runoff formation factors and river runoff.

Climatologists estimated that due to the increased concentration of CO<sub>2</sub> and trace gases the average air temperature grew by 0.5°C by the mid-1970s in comparison with the pre-industrial era and should grow by 1°C by the second half of 1980, by 1.5°C by 2000, by 2.5°C by 2025, and by 3-4°C by 2050. In addition, annual precipitation was expected to rise all over the former Soviet Union, including its southern areas, by 50-100 mm by 2020 and by 100-200 mm by the mid-21<sup>st</sup> century. It was forecasted

that by the late 20<sup>th</sup> century the annual runoff of almost all rivers would decline to 12%, while the runoff of Central Asian, Siberian and Far Eastern rivers would somewhat increase to 13%. The effects of warming on annual runoff variations and potential duration of low and high-water years were unclear at the time. Therefore, the Plan did not include a forecast of water content variations caused by human-induced warming for the rivers in the Aral Sea basin, while the estimates were based on the annual runoff variation factor and unchanged mean runoff calculated based on the restored series of the 1910-1985 period.

Table 2.7 shows total water resources including allowed groundwater consumption.

**Table 2.7**

Total water reserves of the Aral Sea Basin including groundwater reserves (km<sup>3</sup>)

Source: Soyuzgiprovodkhoz, 1989

	River	Multiyear average		90% assured runoff				
		At the time of development of the Plan	2005, forecast	1985	1990	1995	2000	2000-2010
1.	Amu Darya							
	Surface runoff	76	76	62.1	62.1	68.8	68.8	68.8
	Groundwater runoff	1.3	2	1.3	1.4	1.5	1.8	2
	Total:	77.3	78	63.4	63.5	70.3	70.6	70.8
2.	Syr Darya							
	Surface runoff	37.9	37.9	35.3	35.3	35.3	35.3	35.3
	Groundwater runoff	3	3.5	3	3	3	3	3.5
	Total:	40.9	41.4	38.3	38.3	38.3	38.3	38.8
	Total surface runoff	113.9	113.9	97.4	97.4	104.1	104.1	104.1
	Total groundwater runoff	4.3	5.5	4.3	4.4	4.5	4.8	5.5
	Grand total:	118.2	119.4	101.7	101.8	108.6	108.9	109.6

There are other estimates of the Aral Sea basin water resources, which range from 125 to 105.3 km<sup>3</sup>. Thus, for example, total surface water reserves of the Aral Sea basin are estimated at 116 km<sup>3</sup>, of which the Amu Darya basin accounts for 78 km<sup>3</sup>, and the Syr Darya basin for 37 km<sup>3</sup> (Budagovskiy, 1992: 24). According to other studies, estimated water content of the Aral Sea basin based on multiyear periods ranges from 103.7 to 119.9 km<sup>3</sup> (Ivanova, 1992: 41).

The part of the Kara Darya basin runoff is formed on the territory of China, while part of the Amu Darya runoff is formed in Afghanistan and Iran. The respective figures have to be adjusted to take into account data received through joint flow observations in order to properly record this runoff in the water balance of the Aral Sea basin. This is also connected to the fact that

**Table 2.8**

Natural water reserves, runoff and inflow in the Aral Sea basin\*

Source: Ivanova, 1992: 41

Note: Surface inflow into the Aral Sea is a sum of both the Amu Darya and Syr Darya flow into the head of the deltas except for water losses in the deltas. Inflow into the river deltas indicates basin water flowing to the head of the deltas in certain periods (according to A.B. Asarin) \* km<sup>3</sup>/year

Parameter	1926–1940	1941–1950	1951–1960	1961–1970	1971–1985
Water reserves	103.7	113.8	119.9	116.2	109.6
Runoff	43.8	50.5	56.9	70.8	92.2
Inflow into river deltas	59.9	63.2	63	45.4	17.4
Loss in river deltas	6.1	8	7.8	3.9	2.4
Inflow into the sea	53.8	55.2	55.2	41.5	15

Afghanistan plans to rehabilitate irrigation facilities and then develop irrigated farming and hydropower, which entails additional runoff intakes from the Panj river and its tributaries flowing on Afghan territory.

It is a quite complex issue, as until recently water management estimates did not consider Afghanistan as a country intensively developing its water resources, while neglecting its potential share in transnational water apportioning in the Amu Darya basin. According to the Research and Information Centre of the Interstate Commission for Water Coordination in Central Asia, Afghanistan and Iran account for 18.6% of the total water resources in the Aral Sea basin. Water apportioning between other countries located in the Amu Darya basin and the Aral Sea basin as a whole depends on the water use priorities identified by Afghanistan and Iran and the level of water resources they will consume and in which regime.

**Table 2.9**

Natural river runoff in the Aral Sea Basin

Source: SPECA, 2004: 30

Note: multiyear average runoff (km<sup>3</sup> per year)

Country	River basin		Aral Sea basin	
	Syr Darya	Amu Darya	km <sup>3</sup>	%
Kazakhstan	2.426	–	2.426	2.1
Kyrgyz Republic	27.605	1.604	29.209	25.1
Tajikistan	1.005	59.578	60.583	43.4
Turkmenistan	–	1.549	1.549	1.2
Uzbekistan	6.167	5.056	11.223	9.6
Afghanistan and Iran	–	21.593	21.593	18.6
Aral Sea basin (total)	37.203	79.28	116.483	100

The above table shows that 25.1% of total runoff of the Aral Sea basin is formed in Kyrgyzstan, 43.4 in Tajikistan, 9.6% in Uzbekistan, 2.1% in Kazakhstan, 1.2% in Turkmenistan, and 18.6% in Afghanistan and Iran. Overall, the estimates of total water resources offered by the authors are up to 7-8% more or less than the estimates of surface runoff of the Aral Sea basin used in the Plan. Over the past 15-20 years a great number of programmes and projects on the Aral Sea were initiated by international, regional and national organisations. Estimates thereof, however, are not methodologically comparable to the estimates made by the Plan. Weaker government

supervision and a nonoperational stream gauging network in some countries have undermined the reliability of official statistics on annual water intake and consumption. In this regard, the countries of the Aral Sea basin should focus on updating and interpreting the data of the old Plan developed for the Aral Sea basin rivers based on state-of-the-art hydrology observation and research methods taking into account the effects of climate change and human activity on water resources, actual irrigated land and the demographic situation. The joint development of a plan of integrated management and conservation of water resources of the Aral Sea basin is of principal importance as long-term targeted water management, environmental and investment policies and intergovernmental cooperation in respective areas will depend on reliable threshold data on available water resources and water use. The required legal framework is in place as national water laws provide for the development of plans of integrated management and conservation of river basin water resources in all Central Asian states.

Assured water resources in the Aral Sea basin are estimated at 101.7 km<sup>3</sup> or 109.6 km<sup>3</sup> over 2005-2010, which means a potential increase of up to 7.9 km<sup>3</sup>, including 6.7 km<sup>3</sup> through multiyear flow regulation and 1.2 km<sup>3</sup> through the maximum possible (presently estimated) increase in groundwater use without affecting surface runoff. Naturally, based on the estimates made in the Aral Sea Basin Plan, the multiyear average water resources can only grow by 1.2 km<sup>3</sup>, from 118.9 km<sup>3</sup> to 119.4 km<sup>3</sup>, at the cost of increased groundwater use. The data used in the new Plan corresponds with the latest estimates made as part of the Amu Darya Plan (1988) and the Syr Darya Plan (1987) produced by Sredazgiprovodkhlpok (Tashkent), which summarised and adjusted all hydrological data available at the time. As the Plan produced by Soyuzvodproekt stated, the above Plans were reviewed at different levels, and, apparently, the estimates they made of the natural multiyear average water reserves of the Amu Darya and Syr Darya river basin appear to be most reliable.

*Table 2.10* shows estimated water use in Central Asia by 2025 based on the expected dynamics in demographic growth and agricultural and other production to ensure national food security and meet public water demand. It makes it clear that water supply deficit will be a constraint for regional economic development. The forecast covers all major water using sectors, while neglecting the water demand of the Aral Sea as a natural site. In order to save the Sea, the countries of the region should prioritise ensuring that the share of water required for the Aral Sea itself is maintained out of the water consumption limits and deliver on their Sea-related commitments. Each Central Asian state should allocate sufficient water resources from their national water consumption plans to meet the environmental needs of the river basins and save the Aral Sea. This can be done by conserving water resources.

Country	Sectors						Grand total
	Drinking water supply	Rural water supply	Industrial water supply	Fisheries	Irrigated farming*	Other needs	
Kazakhstan	0.16	0.12	0.29	0.17	7.45	0.5	92.9
Kyrgyzstan	0.14	0.15	0.3	0.05	6.8	0.06	7.5
Tajikistan**	1	1	1	0.2	14.5	0.2	18
Turkmenistan	0.47	0.25	1.1	0.04	17.65	0	19.51
Uzbekistan	5.85	1.63	1.46	2.24	48.02	0	59.2
Aral Sea basin, total	7.62	3.25	4.15	2.7	94.42	0.76	112.9

Note: \* Irrigational water demand was calculated based on the efficiency of inter-farm irrigation network (at district borders).  
 \*\* According to the Concept of integrated water resources management adopted in Tajikistan in 2001, the expected total waster consumption may reach 20 km<sup>3</sup>/year by 2025

**Table 2.10**  
 Expected water demand in the Aral Sea basin by 2025 (km<sup>3</sup>/year)

Source: SPECA, 2004: 42

Although not adding to available water resources, the regulation of river runoff is a necessary technical action, which allows the redistribution of river runoff within a year as well as across years in a way that guarantees, in any year and in any season, the demanded water supply, of course, up to 90-93% of the multiyear average runoff (theoretically, over 93% regulation becomes unstable). Consequently, the assured annual surface runoff is 62.1 km<sup>3</sup> in the Amu Darya basin and 35.3 km<sup>3</sup> in the Syr Darya basin, totaling 97.4 km<sup>3</sup> in the Aral Sea basin as a whole. The indicated runoff is 90% assured. In this context, the assured runoff is a relative value expressed in percentages, which shows how many years out of the reviewed period water users will have assured runoff to meet their water demand. This means that water users in the Amu Darya and Syr Darya basins have an assured annual runoff of 62.1 and 35.3 km<sup>3</sup> respectively (90 out of 100 years); in other years the assured runoff could be up to 20% less than the assured annual runoff. This is exactly the rationale behind all operational and future reservoirs in the Amu Darya and Syr Darya basins. The 90% assured runoff is taken as a standard in the basins, because, unlike drier areas with 75% assured runoff, agriculture can only be developed on irrigated land and cannot depend on low precipitation. Water reservoirs located in the area can only be filled up if water release limits are calculated based on canal water intake limits. Most reservoirs were built over 30 years ago. As the silt accumulated in the reservoirs over their life cycle, the reservoirs lost much of their projected active storage capacity. This means that the above estimates of reservoir storage capacity should be reduced, and river runoff control adjusted accordingly.

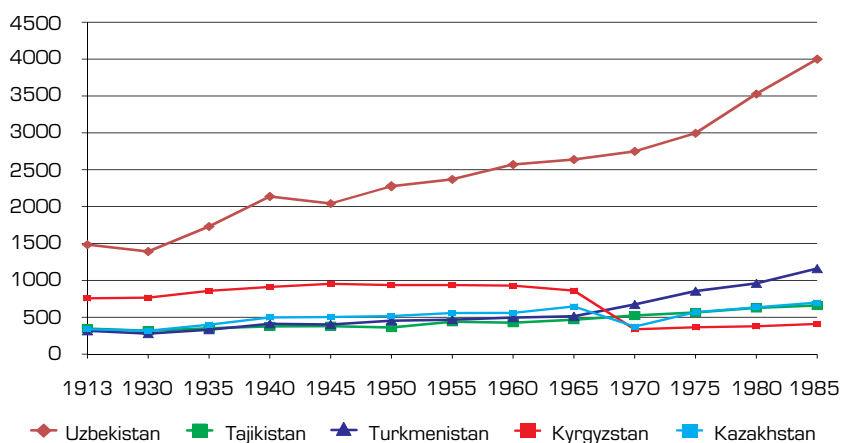
Overall, the estimated variations of Central Asian water resources and water consumption differ insignificantly in terms of actual figures. All of them, however, indicate potentially increasing water consumption and, as a result, growing

water supply deficit in the region. At present, the available water resources are used in the economic turnover to the full, while the ever-growing water supply deficit will entail a deteriorating quality of water if adequate measures are not taken. In this context, Central Asian countries should use a coordinated approach to their long-term water consumption taking into account the need to conserve the quality of water and ecosystems of transboundary rivers and implement water saving policies at a national level.

## 2.4. Regional development of irrigation and challenges of irrigated agriculture

The majority of the population of the Central Asian countries resides in rural areas, from 43% in Kazakhstan to 75% in Tajikistan. The economic well-being of the rural population depends on the effectiveness of irrigated agriculture. Up to 60% of rural population is employed in agriculture, the most important contributor to the national economies.

Areas suitable for cultivation total 59 million ha, of which 10 million ha are actually used. Half of the actually cultivated land is in oases, which are drained and have fertile soils. Another section of potentially suitable lands requires complex and costly reclamation works, including both drainage and leveling as well as soil improvement. Coupled with the shortage of water supply, the situation causes natural disagreement both at international and national levels, especially in areas with unequal demographic load.



**Figure 2.14**  
Irrigated land in the Aral Sea basin (growth dynamics)

Source: Soyuzgiprovodkhoz, 1989

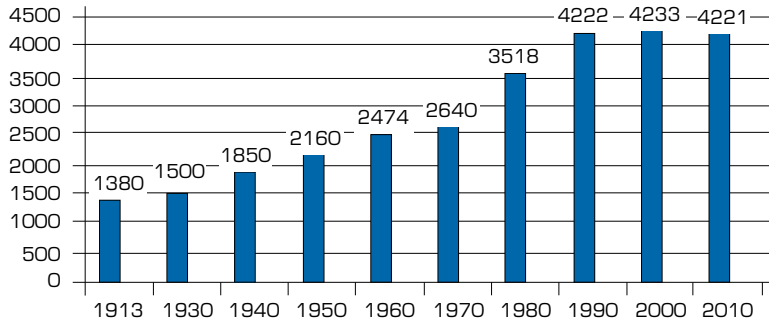
Note: \* starting from 1970. Continental rivers of Kyrgyzstan were not taken into account; \*\* only South-Kazakhstan and Kyzylorda oblasts of Kazakhstan were taken into account

The actual rates of irrigated agriculture development and use of basin water differed notably from those planned. Over 280,000 ha of new lands were turned into irrigated land over 1976-1980 with another 180,000 ha over 1981-1985 and 1986-1990, although the planned indicators were much lower. By 2000, the actual area of irrigated land in the Syr Darya basin reached 3.32 million ha versus 2.66 million ha in 1975, which means an increase in

irrigated land by 660,000 ha with the unchanged available water in the river, the irrigation capacity of which was exhausted back in 1975. Moreover, water consumption for domestic and industrial needs grew due to urban population growth and industrial development. The situation changed after the collapse of the USSR; however, water consumption is still increasing, slowly but steadily, primarily for agricultural needs.

**Figure 2.15**  
Irrigated land in  
Uzbekistan (growth  
dynamics)

Source: RU, 2011



More and more lands have become irrigated in the Amu Darya basin: 529,000 ha, 560,000 ha, 306,000 ha, 470,000 ha and 155,000 ha every five years since 1975. Over the past decade most of the newly irrigated lands were in Turkmenistan, while in other CA countries irrigated land grew insignificantly, and in others it did not grow at all. By 2000, irrigated land in the Amu Darya basin reached 4,714,000 ha, with another 3,324,000 ha in the Syr Darya basin, totaling 8,038,000 ha in the whole Aral Sea basin (Royal Haskoning, 2003).

Almost the entire agricultural production of Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan and southern Kazakhstan is based on irrigated land, of which 4.4 million ha are in Uzbekistan.

The Ferghana Valley is an important irrigation and industrial region of Central Asia spread over Kyrgyzstan, Tajikistan and Uzbekistan. The valley is shaped as an ellipse 80-120 km wide stretching over 300 km from east to west.

As noted above, the major river in the Ferghana Valley is the Syr Darya, which flows south-west and divides the valley into two unequal parts, a greater southern part and a lesser northern part. The river bed lies at the lowest points and cuts into the base of the valley; sands join the river bed over a significant stretch. Therefore, the majority of irrigated lands of the Ferghana Valley are not along the river and are irrigated from the rivers forming the Syr Darya, such as the Kara Darya and the Naryn rivers (in the upper western part of the valley), and its multiple tributaries such as the Sokh, the Isfara, etc. All of these are used fully for irrigation through a fan-shaped set of irrigation canals. The same goes for tributaries of the Kara

Darya – such as the Malisai, the Kara Bura, and the Aravansai (Frolov, 1965: 216).

At the beginning of the 20<sup>th</sup> century, the oasis was irrigated by radial irrigation canals on the alluvial fans of the Syr Darya's tributaries. The largest were the Sokh, the Isfara, the Isfairam, the Shakhimardan and the Andijan. Some small areas were irrigated from the Naryn, the Akbura and the Aravan-sai.

Region/country	Territory	Suitable for irrigation	Used for irrigation			Unused land
			1930	1970	2000	
Ferghana valley, including	9,053	1,539	675	1,066	1,375.9	163.1
Kyrgyzstan	6,408	341	162	214	330.7	10.3
Tajikistan	699	197	39	97	133.9	63.1
Uzbekistan	1,946	1,001	474	755	911.3	89.7

**Table 2.11**  
Irrigation of the  
Ferghana Valley  
(thousand ha)

Source: RU, 2011: 28

Unreclaimed land stretched over the vast areas of Central Ferghana, which experienced a very limited water supply. As new lands were reclaimed, the entire irrigation network was renovated and turned into a public utility network. From 1954, Uzbekistan shifted from irrigation of small areas to large-scale reclamation of virgin land stretching over tens and hundreds of thousands of hectares, most of which was in desert or semi-desert uninhabited regions with a difficult climate.

Efforts were focused on the development of irrigation in the country's major oases. It was the period when water resources and irrigation were managed by the central government and financed out of the state budget. Costly, complex irrigation and drainage construction was initiated based on feasibility considerations regardless of potential return and cost recovery by the primary users.

As a result, a four-line system (including the Grand Ferghana Canal, the South Ferghana Canal, the North Ferghana Canal, the Grand Andijan Canal and the Grand Namangan Canal constructed later) was built to feed the Ferghana Valley. A major shortcoming of the period was the neglect of the interaction between irrigation on different altitudes, which led to a groundwater rise, waterlogging and the salinisation of lands in the central part of the valley.

By the 1970s, most of the fertile land in the Ferghana Valley was reclaimed. Post-1970 irrigation development included reclamation of high-altitude valleys and adyrs requiring complex pump irrigation arrangements and prone to erosion, which eventually led to additional reclamation works that made irrigation facilities even more complicated and costly (RU, 2011).

It is important to note that the majority of irrigated land is on a lift irrigation area with upward-looking terraces. This gave rise to pump irrigation in Tajikistan and Uzbekistan. Presently, pumping stations handle over 80 km<sup>3</sup> of water per year. The region's pumping facilities constitute a cost and energy intensive sector of irrigation. Agriculture accounts for nearly half of energy consumption, of which 50% is energy used by pump motors. Uzbekistan is one of the world's leading users of pump irrigation with pump irrigation servicing 2.2 million ha and nearly half of the region's pumping facilities. In Uzbekistan, there are 43 large, about 1,400 medium and 30,000 small pumping facilities handling over 6,500 m<sup>3</sup>/s of water annually with a capacity of over 60 km<sup>3</sup>. For that, up to 5,500 tonnes of diesel and 7.5-8.5 billion Kwh of energy is used, which accounts for 20% of energy allocated



**Figure 2.16**  
Qarshi irrigation system

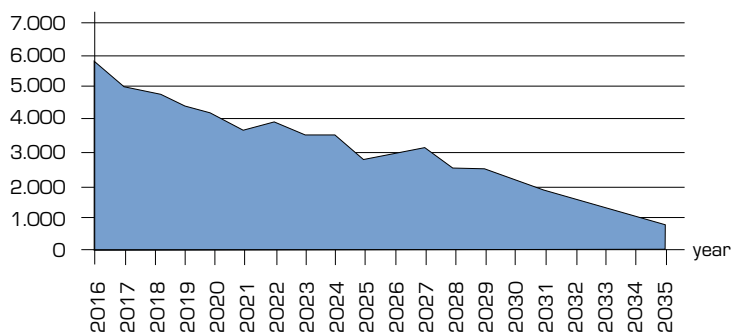
Source: UNEP, 2011;  
ZOI Environment Network, 2011: 35

for sectoral uses. In the long-term, it is possible that flow irrigation will be used on up to 7-8% of irrigated land.

For example, the Qarshi pumping cascade lifts 200 m<sup>3</sup>/s of water up to 132 m, for irrigation of 350,000 ha; the Amu-Bukhara Canal lifts 263 m<sup>3</sup>/s of water up to 69 m, for irrigation of 285,000 ha (Ikramov, 2000). Uzbekistan and Turkmenistan share the Qarshi and Amu-Bukhara pumping cascades and the Tuyamuyun Reservoir, both situated in Turkmenistan. The Qarshi pumping cascade was built between 1973 and 1988. The cascade consists of the Talimarjan Reservoir and seven pumping stations, six of which are in Turkmenistan. The pumping stations using over 2.2 billion kWh of energy per year and lift 5 km<sup>3</sup> of water to irrigate the Qarshi Steppe and supply water to large urban areas and industrial enterprises located in the Kashka Darya province of Uzbekistan. Overall, the Qarshi pumping cascade ensures water supply in a territory with about two million residents and an annual output of 1 million tonnes of grain and 0.5 million tonnes of cotton (UNEP, 2011).

In Central Asia pumping facilities operate in very difficult conditions predetermined by the high concentration of suspended solids in handled water (6-15 g/l), high temperatures (35-50°C), and the year-round cycle (the filling of water reservoirs, washing, irrigation, etc. in winter). Drainage facilities have to handle highly saline water (up to 25 mg/l). Frequent power cuts and other technical malfunctions have a negative influence on the pumping equipment. This leads to the poor efficiency and frequent repairs of pumps (Glovatskiy, 2000: 32-41).

In Central Asia water resources are estimated to deplete both quantity and quality wise. This urges a comprehensive approach to ensuring water and energy supply in all sectors of regional economy. One of the solutions could be improved cooperation between CA countries and integrated water resources management. Through this method, the need that Uzbekistan and other Central Asian countries have for energy for pump irrigation could be covered by the energy surplus that occurs during reservoir releases in Tajikistan and Kyrgyzstan. A study on the subject matter conducted by SNS-



**Figure 2.17**  
Annual average energy surplus in hydropower stations in Kyrgyzstan and Tajikistan (GWh)

Source: CASA, 2011

Lavalin International Inc. indicates an export surplus of hydropower worth 6,000 GWh, which almost always falls in the summer months. With no plans to boost hydropower output or increase energy demand, the surplus will be reduced to 900 GWh over the next 20 years.

As the estimates imply, the development of available hydropower capacity in the countries under review could cover all the energy demands for farming irrigated by pump irrigation in the region, ensure long-term runoff control, and, eliminate or reduce potential damage inflicted during low-water periods or droughts. Moreover, the solution will enable the operation of the Central Asian Unified Power System and investment in energy infrastructure, which has depreciated by more than 70%. It is important to note that the arrangement enables hydropower resources to remain in the region, which will eventually ensure its energy, food and environmental security. In a market economy integrated water and energy resources management has to be scientifically substantiated and based on the economic integration of all Central Asian countries and a watershed approach.

More water resources are being used as irrigated land expands in the CA river basins. In 1960 water intake in the Aral Sea basin reached 60.61 km<sup>3</sup>; it grew by 1.8 times by 1990 reaching 116.271 km<sup>3</sup>. Over the same period the population grew by 2.7 times, irrigated land by 1.7 times, and agricultural output by 3 times. In 1980 consumptive water use totaled 120.7 km<sup>3</sup>, which exceeded the cumulative runoff of the Amu and Syr Darya river basins. In 1981-1987 the rate of irrigated land development remained the same as during the past five years, which led to growing irrigation needs, which reached its maximum in the mid-1980s. In 1985 consumptive water use in the Aral Sea basin totaled 126.9 km<sup>3</sup>, of which irrigation accounted for 115.9 km<sup>3</sup>.

Since 1994, water intake and consumption has tended to decrease. In 1999 total water intake was 104.955 km<sup>3</sup>, which was 11.4 km<sup>3</sup> less than in 1990. In addition to temporary stagnation, water consumption was reduced due to increased grain cropping coupled with reduced arable land under wet crops such as cotton, rice, and fodder grass. An increase in irrigation water consumption was recorded as the national economies got back on track, and the long-term decline in agricultural production halted. At the same time, the reclamative capacity, or quality, of irrigated land is still declining. The regional water deficit can be largely attributed to ineffective management of irrigation facilities, which causes significant agricultural loss. The loose agrotechnical requirements for agricultural cropping and the poor technical condition of irrigation facilities leads to low yields and inefficient water use. For example, 30% more water is used per one hectare of Central Asian territory in the Aral Sea basin than in other countries like Egypt and Pakistan.

Around 12% of the irrigated lands in Central Asia are areas with a large natural drainage capacity, most of them being foothill plains, irrigation of

Country	Syr Darya basin	Amu Darya basin	Aral Sea basin*
Kazakhstan	206	–	206 (0.7%)
Kyrgyzstan	81	–	81 (4.3%)
Tajikistan	58	112	170 (10.6%)
Turkmenistan	–	378	378 (6.1%)
Uzbekistan	390	529	919 (9.3%)
Grand total	735	1019	1754 (3.6%)

**Table 2.12**  
Estimated  
agricultural loss  
due to ineffective  
irrigation  
management  
(\$ billion per year)

Source: UNDP,  
2005: 106

Note: \* Bracketed  
percentages indicate  
total loss as  
% of GDP in 2003

which does not cause groundwater rise. The soil cover is represented by, primarily, light and dark sierozem, grey-brown soil and non-saline, somewhat wind-eroded, rank and rocky soils of various mechanical compositions. Most of these lands have a thin layer of earthly matter (30-100 sm) and gravel and pebble deposits, which largely limits the use of the land for irrigated farming.

Lands in fine reclamative condition account for up to 52% of irrigated land. These lands are drained by artificial drainage of varied complexity and quality. The soil cover is represented by meadow-desert, meadow takyr, and meadow sierozemic soils, and less often grey-brown, light, typical and dark sierozemic subsaline soils of various mechanical compositions, and is affected by irrigation erosion in some sections.

Around 21% of irrigated land has a poor reclamative condition entailing groundwater depth close to the surface (only 1-2 m) and different soil disturbance indexes. These lands also include meadow-desert, meadow takyr, and meadow sierozemic and light sierozemic soils of medium salinity, eroded and blown to varying degrees.

Up to 15% of the irrigated land in the Aral Sea basin is in a very poor condition. This includes poorly drained, closed drainage areas, often without artificial drainage arrangements, with alkali groundwater flowing close to the surface. These also include highly (and less often extremely highly) saline meadow-desert, meadow takyr, meadow sierozemic soils combined with solonchak and semi-fixed sand dunes, which are sometimes affected by irrigation erosion.

Moderately and highly saline lands nearly doubled over the 1965-1985 period, reaching 2.8 million ha, while the overall share of this type of land as a portion of all irrigated land remained unchanged. An average of 300-450 kg of mineral fertilisers were spread over each hectare of irrigated land in Central Asia versus an average of 30 kg per ha across other USSR countries. 54.4 kg of pesticides (including insecticides, herbicides, and defoliants) were spread over 1 ha – 25-30 times more than in other Soviet countries. Plants only absorb 35-40% of nitrogen, and the remainder turns into unavailable forms and mixes into groundwater and surface water. It then causes high concentrations of nitrates and ammonium salts in agricultural produce from the same land. Only 1% to 4.1% of pesticides are washed out

of irrigated land. Through the soil-water-plant chain, these pesticides travel to living bodies where they accumulate in concentrations that are much higher than those in the chain elements. Extensive areas of irrigated land are contaminated with phenols, petroleum hydrocarbons, and microelements transported by irrigation. The content of these elements in the soil is several times more than the permitted concentration. All of this occurs against a backdrop of decreasing soil productivity, entailing thinning humus content and disturbed biocommunities.

Environmental deterioration and the deteriorating quality of surface water is closely linked to the status and quality of groundwater. Estimated groundwater reserves in the Syr Darya and Amu Darya basins vary greatly. The bulk of the reserves are formed as a result of irrigation. There are over 250 groundwater deposits identified and proven in the Aral Sea basin, most of which depend on surface water.

Groundwater in the Aral Sea basin is prone to salinification and pollution. Organoleptic indicators of groundwater change due to salinisation, and toxicological indicators change due to pollution. These indicators are particularly poor in the lower course of the Amu Darya, Syr Darya, Zeravshan and other rivers. Usable groundwater resources have notably decreased, which underlies the need to shift from extensive use to sound groundwater management practices. To do this, a comprehensive inventory of proven groundwater deposits is required, one that does not estimate reserves. Whether or not to include proven groundwater reserves when compiling a water balance should also be carefully considered.

A peculiar feature of the previous decades is that water demand exceeds accessible and available river water reserves, particularly in the low-water years. Steady population growth entails a growing number of water users, which leads to increased diversion of water from the rivers and decreased available water resources. At the same time, many researchers note that there is sufficient capacity to manage the water demand of agricultural crops and reduce the unproductive loss of water. Losses within irrigation systems and during irrigation have a large impact on agricultural water supply. Only 43% of water diverted from the Syr Darya basin and 37% of water diverted from the Amu Darya basin actually reaches the crops. Greater losses require greater water intake as well as measures to maintain the reclamative capacity of irrigated land and the disposal of waste water out with irrigated land. According to Uzvodproekt (1993), waste water disposal accounts for 39% of overall water intake, and for the Syr Darya and Amu Darya basins this indicator is as high as 51% and 31%, respectively. 32% of waste water disposed in the Syr Darya basin and 33% of waste water disposed in the Amu Darya basin are discharged outside irrigated lands and are practically lost as a potential resource. The quality of return waters is significantly deteriorating;

therefore, unproductive loss of irrigation water should be reduced to help manage a growing water crisis. The existing water accounting system fails to show the share of drainage and discharge water in the overall volume of disposed waste water. Estimates suggest that irrigated water discharge into the collector and drainage network accounts for the majority share of disposed waste water, 65% and 69% of total waste water disposed in the Amu Darya and Syr Darya basins, respectively.

A growing demand for water should be balanced by water conservation practices. Water conservation does not impact natural water reserves in the Aral Sea basin. The first stage of addressing a water crisis in the region should involve improved water management to reduce non-recoverable transportation losses. The introduction of water conservation technologies will add to the cost of each cubic metre of water; therefore, at this stage, only low-investment water conservation technologies should be applied. In the longer term, country-wide application of the best technologies and practices coupled with overall reclamation of irrigated land is a viable alternative solution to the water crisis in the region.

According to Uzvodproekt (1993), potentially reduced losses can be broken down by elements of irrigation systems as follows:

- 25% – irrigation practices;
- 30% – on-farm irrigation canals;
- 45% – off-farm and central irrigation canals.

Climate scenarios that reflect “global warming” do not involve an increase in the Amu and Syr Darya runoff; quite the opposite: the runoff is expected to decrease in the crop season. The most pessimistic estimates of the runoff of the major rivers in the Aral Sea basin suggest that the Syr Darya river runoff will decrease by 15-20% and the Amu Darya runoff by 20-30% due to global warming and a reduction in mountain snow and ice reserves (Khorst, 2002: 60-91).

The key provisions of the 1989 Plan (Moscow) were short-lived, however, the conclusions and recommendations are still relevant for water management policies today. The Plan suggested the causes of reclamative and environmental degradation in the Aral Sea basin.

Extensive irrigated farming in the poor hydrogeological conditions of arid zones impacts migration of soluble salts by feeding groundwater and washing out accumulated salt. The Syr Darya and Amu Darya waters deteriorate on their way to the Aral Sea as they mix with waters flowing from saline structural lows formed as a result of the construction of irrigation systems. In the upper sections, river water forms groundwater,

while in the lower sections, before a tectonic barrier along the flow of groundwater, the rivers receive saline water.

To further develop irrigated farming, new areas with poor reclamative capacity were used, including closed drainage areas, areas with great salt build-up, aeration zones with a hard soil lithology, poorly washable saline soil, etc.

Irrigated farming was also started on old gypsiferous soils affected by long periods of desertification with poor fertility, high cultivation costs and poor reclamative capacity.

Foothill plains with thin earthy matter layer, poor productivity and moisture-retaining capacity and great infiltration losses were used to crop cotton and medic. These water logged areas are situated in the groundwater discharge zone.

The share of unproductive land in irrigated lands has reduced, while the dry drain formerly occupying 60-70% of irrigated land was eliminated completely.

Intensive agricultural development has resulted in the disappearance of fallow lands, which had previously enabled soil self-cleaning, increased soil buffer capacity and base exchange capacity preventing self-reproduction of soil fertility. All of these had a naturally negative effect on the reclamative capacity of old-irrigated soil and reduced the yield, particularly in recent years.

The old irrigation systems had significant unproductive losses of irrigation water at all stages due to their poor technical condition and unsound water management practices.

The industrialisation of agricultural production notably lagged behind the industrialisation of construction when new areas were reclaimed. An important factor in the environmental deterioration has been the cotton policy that sought to increase cotton yields. Over the past 15-20 years cotton took over almost half of vegetable and fruit farming areas, which in turn disturbed crop rotation. Monocultural farming impacted the soil status by reducing humus reserves by 30-40% and soil fertility to the critical level.

The increased use of mineral fertilisers to combat the decreasing soil fertility failed to boost cotton yields, which reduced from 25.2 to 23.6 centner per ha, while contributing greatly to the environmental deterioration of irrigated land.

Inadequate investment in reclamation works, such as drainage, lining of irrigation canals, automation, etc., unsound management of systems, and the lack of a reliable mechanism for reclamative and environmental forecasts at the stage of designing reclamative facilities (Soyuzgiprovodkhoz, 1989) all had an impact.

Irrigation challenges have a significant effect on the land use, degradation and desertification. It should be noted that all Central Asian countries have similar land management problems such as the restructuring of agriculture, changing patterns of ownership, the degradation of arable land, rangeland, hayfields and forest, shrinking usable land, legislative defects, a lack of rural expertise, low land management awareness among new farmers and limited environmental awareness.

Factors causing degradation and the types of degradation are also similar. They include the non-use of traditional land management practices, monoculture, wear and tear, as well as the failure of irrigation and drainage systems accompanied by declining land reclamation, extensive animal farming, a growing livestock inventory resulting in overgrazing around human settlements and underuse of remote pastures. All five countries experience increasing erosion processes, the deteriorating fertility of arable land and the resulting low crop yields. All countries have vast territories of rangeland in conditions of overstocking, requiring improvement.

Climatic changes such as increasing aridity and frequent drought, combined with ineffective management, also cause the degradation of deserts and semi-deserts vulnerable to human impact in Kazakhstan, Uzbekistan and Turkmenistan.

Increased irrigated land led to the development of barely usable or unusable marginal land. In addition to some positive results, irrigated agriculture caused many problems in Central Asia. After the redistribution of large state farms among multiple farmers and other owners, many irrigation and drainage systems were left without organised maintenance, which, coupled with the lack of resources for maintenance works on irrigation and drainage systems contributed to secondary salinisation and further reclamative deterioration of irrigated land. Up to 50% of irrigation water is lost to filtration and leakage in irrigation pipes. All Central Asian countries have faced the challenge of significantly decreased crop yields due to salinisation and waterlogging and great water loss on irrigated land. Since 1990 crop productivity has decreased by nearly 48%: sugar beet by 52%, cotton by 39%, potato by 26% and vegetables by 34%.

Land degradation causes a wide range of social and economic issues. Decreasing land productivity leads to significant economic losses in all sectors of agriculture involving the use of land. According to the Third National Report of the Republic of Kazakhstan on the UN Convention to Combat Desertification, Kazakhstan lost an estimated annual amount of \$6.2 billion as a result of the direct and indirect effects of land degradation.

Agricultural development was boosted at the cost of expanding irrigated lands. This contributed to an environmental crisis in the region, to mitigate

which agricultural development based on higher land productivity and irrigation water conservation should be strategically envisaged at the regional and national level.

The plan provides for the sound management and conservation of water resources and irrigated lands, which entails:

- reassessing the reclamative capacity of lands based on new criteria and approaches to land resources use and conservation and keeping salt accumulating lands untouched. It is well-known that depressions, particularly in contact points such as the lower sections of delta and dry delta, are natural salt receivers. When these lands are reclaimed and irrigated, the salt accumulated deep down is released and resalinises soil and groundwater. These lands account for around 20% of irrigated land;
- scientifically substantiating the ratio and schedule for mineral fertilisers and pesticides taking into account state-of-the-art agricultural and agrochemical practices;
- adjusting agricultural production to the region's natural conditions. Any adjustment should, in particular, cover foothill plains, which account for 4% of irrigated land, and are used for cotton cropping irrigated by furrow irrigation. This leads to great water loss and the water logging of lower lands. It makes sense to use this land for orchards and vineyards irrigated by drip irrigation, which has, in some instances, turned into a highly-profitable farming businesses. Paddy fields should also be adjusted (around one third of paddy fields should be used for a different crop);
- ultimately enhancing the productivity of irrigated land. Scientifically established crop rotation schemes should be introduced on cotton producing lands in order to restore the biological activity of the soil;
- improving reclamative condition of irrigated land. Irrigation and drainage systems should be renovated. Land drainage should only be used to maintain the fixed depth of groundwater by diverting the lowest possible volume of collector and drainage water. Another important area of work is improving the irrigation and leaching;
- developing quality standards for irrigation water for different soils and crops. The quality of irrigation water should be factored into the renovated irrigation systems, irrigation schedules and water consumption rate;
- developing new state-of-the-art regulatory and procedural guidelines, including relevant methodology and techniques to make reclamative and environmental forecasts, etc, to design new and renovate existing irrigation facilities and take comprehensive melioration measures;

- developing innovative practices enabling the sound management and conservation of water and land resources.

In addition to the above recommendations, we believe it is necessary to develop and approve, at a regional level, standard requirements to compile threshold information on the status and use of water resources, correct existing and develop missing regulatory and procedural guidelines. It seems advisable to shift to scale-adjusted e-maps and software enabling practical use of e-maps. Multizone GPS surveying and space sensing methods should be used to assess the environmental and reclamative condition of irrigated land.

It is important to adopt a methodology that will be universally applied throughout the region to define water balances and create water management and water-power designs. It is necessary to develop guidelines to determine water quality targets for water bodies and water diversion quotas for transboundary water bodies. The maximum consumptive use of surface runoff in transboundary river basins should be scientifically substantiated.

These conclusions have been reiterated and many recommendations expanded in the Aral Sea projects and programmes commissioned by international and national organisations working in Central Asia. For example, the SPECA programme focuses on the water quality and salinity. It reports that in Central Asia intensive development of irrigated farming and drainage coupled with increased use of water for industrial and domestic needs has led to increased consumption of fresh water and increased discharge of pollutants together with return waters into the water bodies.

The main pollutants are left-over agrochemicals, which flow into the drainage system and mix into the water. The second pollutant is waste water from municipal and industrial sewage systems. Groundwater pollution also results from inefficient maintenance of landfills of domestic and industrial waste, especially those of the mining industry. The statistics of the quality of river water over the past 40 years indicates increased salinity levels both in terms of time and in terms of river bed length. For example, maximum water salinity in the Amu Darya delta was 1 g/l in the 1960s versus current records of 0.3–0.5 g/l in the upper course and 1.7–2 g/l in the lower course.

Both salinity and composition determine if water can be used for irrigation. The increased salinity of river water and more intensive drainage from irrigated land have significantly affected the dynamics of the salt regime and reclamative capacity of irrigated lands. The link between the salinity of river water and reclamative conditions of irrigated lands allows the identification of areas where salt builds up, which includes increasingly unproductive lands or

lands with the least tolerable productivity. Therefore, a steadily changing ionic composition of water salinity in the middle and lower course of the Amu and Syr Darya should be regarded a negative trend as it leads to a threateningly increasing alkali content.

Alongside increasing water salinity, the level of content that includes elements like magnesium, cuprum, ferrum, sulphates, and chlorides is also growing. This results in surface water in both the lower and middle course of the Syr Darya becoming unsuitable for drinking. Extensive pollution of the river as a source of drinking water translates into growing disease incidence rates. In particular, the incidence rates for diseases such as hepatitis, typhoid, and diarrheal diseases, which are all caused by the low quality of drinking water.

Some reduction in water salinity in transboundary rivers was registered in between 1990 and 2000 and caused by a temporary reduction in water consumption for irrigated farming and industrial needs. Today, groundwater deposits are tending to become increasingly contaminated. For some elements, the groundwater contaminant concentration exceeds the maximum allowable concentration ten-fold, while in some sections hundred-fold. Groundwater is most polluted near large urban areas as well as chemical, oil processing, nonferrous metallurgical and other plants. Statistics suggests that on average 8% to 15% of water samples are below the bacteriological standards, while another 20% to 40% of water samples are below the physicochemical standards. The technical condition of water treatment facilities remains unsatisfactory with 60-70% of them failing to effectively treat sewage and industrial runoff.

To improve the quality of water, the following measures should be taken:

- limit waste water discharge into rivers and discharge of certain pollutants into different cross-sections and zones;
- introduce into transnational practices the polluter-pays-principle (in the event of a disrespect for the limits);
- intensify water quality control;
- determine environmentally sound discharge limits for transboundary rivers in different water years and time periods;
- improve the methods and means of monitoring water quality.

Land degradation results in a reduction in cropland in all CA countries. There are many factors contributing to this; they can be grouped into two major groups. The first group includes natural and climate factors such as global warming, relief conditions such as the steep slopes and depressions with no groundwater drainage, and dry land. The second group includes factors related

to human activities involving unsustainable use of land and water resources and disrespect for environmental requirements. The following factors must be emphasised:

- ploughing of large rangelands and the allocation of land for non-agricultural needs such as construction, roads, electric power transmission lines, industrial facilities, urban and rural expansion, and residential development;
- use of unproductive land for irrigated farming without prior reclamation and excessive use of groundwater;
- salinification and water-logging of lands resulting from inefficient irrigation and cropping, and the discharge of drainage water into rangeland;
- deforestation and overstocking, which contribute to desertification;
- droughts and low-water periods, which are cyclical climatic and hydrological events involving an abnormal rise in air temperature and a reduction in surface runoff (three to six times in a decade);
- reduction in farmland due to the shrinking of the Aral Sea (environmental deterioration in the downstream reach of the Amu Darya and Syr Darya and spread of salt and dust over extensive areas);
- ineffective rate of land reclamation in environmentally unsafe regions as well as areas under industrial and domestic waste and the tailing pits of the mining industry.

Today, the area of irrigated lands, including second crop lands, in the Amu Darya and Syr Darya basin is much more than the recommended value. The resulting volume and patterns of water use affect water inflow into the Lesser and the Greater Sea, which is plummeting, particularly, in low-water periods. Resolution no. 1110 of the CPSU Central Committee and the USSR Cabinet dated September 19, 1988 "On Measures to Improve Environmental and Sanitation Situation in the Aral Sea Region and Enhance the Sound Use and Protection of Water and Land Resources in the Aral Sea Basin" is still relevant today. The resolution urges the restoration of the environmental balance in the Aral Sea region, the saving of the Aral Sea with its shrunk basin as a natural site that has a significant effect on the environment and climate of the region and improvements to the sanitary and epidemiological situation. For this purpose, a minimum water inflow into the Amu Darya and Syr Darya deltas and the Aral Sea should be guaranteed at 8.7 km<sup>3</sup>/year starting from 1990, 11 km<sup>3</sup>/year by 1995, 15–17 km<sup>3</sup>/year by 2000 and 20–21 km<sup>3</sup>/year, including collector and drainage water, by 2005. It should be noted that when the drainage networks were first built in the Aral Sea basin, the idea

Problem	Factor	Effect
Ineffective agricultural zoning	Raw cotton production orientation	Extensive agriculture, ineffective land use
Salinification	Lack or ineffective use of collection and drainage network	Deteriorating productivity, increased use of irrigation water, agents, fertilisers and labor
Stoniness	Reclamation of stone land	Decreased productivity, increased use of irrigation water and labour
Gypsification	Reclamation of gypsiferous land	Water logging, low productivity, salinification
Ineffective cropping patterns	Monocultural farming of cotton and wheat	Lack of crop rotation, decreased productivity, increased use of fertilisers and pesticides
Irrigational erosion	Ineffective irrigation practices, reclamation of slope land	Degradation, washout and removal of fertile soil layer
Wind erosion	Lack of effective field-protecting forest belts in wind-stirred areas	Reduction of yields, wind shifting of fertile soil layer
Reclamation and use of highly salinised unproductive lands	Development of water-intensive agriculture	Ineffective land reclamation and use
Water erosion	Farming of steep slopes, plowing over a number of years, lack of crop rotation on dry lands	Firming of soil, structural damage, washout, degradation, gullying

**Table 2.13**  
Main problems and factors of land degradation in Central Asia

Source: ICARDA, 2009.

was to exclude the discharge of collector water into the rivers. In particular, this approach underlies the decision to fix the water salinity of the Syr Darya at the point where it enters the Chardara Reservoir at 1 g/l, which means that collector and drainage water should not be discharged outside water districts, while the Aral Sea should not be a collector for these waters and toxic substances from the entire drainage area (Kuznetsov, 1991: 85-87).

# Use of water resources and water power engineering in the transboundary river basins in Central Asia

## 3.1. Use and management of hydropower resources

The management of water resources requires that water resources be stockpiled and then redistributed through the creation of manmade bodies of water. In any event, it is through the construction of artificial structures, that water is ultimately distributed to its place of consumption or alternatively accumulated for a specific purpose.

In contrast to natural features (seas, rivers, lakes), which came into existence through evolution over an extended period of time as a component of the surrounding environment (with the exception of bodies of water formed from earthquakes or landslides (e.g. landslide lakes)), artificial bodies of water (reservoirs, canals, etc.) are built in what is comparatively a very short time.

The natural flow of rivers is characterised by an extremely unequal distribution over the course both annually and over decades. The flow distribution does not coincide with the demands of most sectors of the economy. Thus, an even flow is preferred for energy needs in the long-term. In an annual context, hydro-plants place an increased demand for water during the autumn and winter months when the river water flows are at their lowest. On a day-to-day basis, the load demand on a HPP is uneven and varies significantly whereas the river inflow during this time usually varies only slightly.

All of this leads to the need for redistribution of the natural flow over time in order to best meet customers' needs. This is accomplished by regulating the flow with reservoirs, which retain the excess natural flow when it exceeds customer demand and release flow when demand is higher than the inflow. Under the current conditions, the streamflow is used by several sectors of the economy simultaneously and therefore any hydraulic structure that is connected to streamflow regulation has an integral role. Except for energy management purposes, HPP reservoirs are generally used for water resource

purposes like irrigation, water supply, etc. There are a number of facilities that mainly pursue water resource goals while addressing energy objectives at the same time.

Hydropower management and water resources management are different. Hydropower management, or more properly energy management, performs the redistribution of flows for energy purposes. It ultimately allows the desired HPP capacity, and consequently the desired turbine output, to be achieved. HPP capacity is a function not just of discharge but also of pressure, which is why the process of regulating the flow of energy accounts for changes in both. Pressure is not a controlled variable in water resources management and only discharge can be regulated. This is the main difference between energy and waterworks management.

The energy streamflow is determined by the optimisation of the power system, or, in other words, the calculations to determine the optimum conditions for the electric power system are inseparable from the calculations for the HPP reservoir energy streamflow. Under integrated river basin development, when resources are used for both energy and non-energy purposes, integrated management is exercised, for example, over HPP pressure and discharge and only discharge for other water users.

Naturally, the calculations for the transition from water management to integrated regulation become significantly more complicated. Thus, the essence of the energy management process is that there are periods of time when the HPP at hand is working with a flow rate that is greater than the inflow and at other times it expends less water than the inflow. In the first scenario there is a drawdown from the reservoir and in the second, the reservoir fills. The time interval from the initial period of drawdown from the reservoir to the beginning of the next period – after a subsequent refilling – is called a control cycle. The duration of the energy control cycle determines its type: a short-term control cycle or a long-term control cycle. The first type usually covers daily and weekly control cycles while seasonal, yearly and multi-yearly cycles are of the second type (Obrezkov, Grokhman, 1973: 42-44).

The creation of reservoirs, hydropower plants, water transport arteries (canals), and irrigation and drainage channels changes the state of water resources and the related natural bodies of water. Changes to the quantitative and qualitative state of water resources for household use also have a significant impact on the environment. Every body of water has an impact on the environment and its components that depends on its destination. Therefore one of the main objectives in water resource management planning is to provide a balanced method of exploitation, which allows profit to be derived and the necessary quality and quantity of water to be supported, while also decreasing the negative impacts on natural bodies of water.

The state of water bodies, primarily artificial ones, has a key influence on the environment. Thus, the artificial bodies of water in CA should be regarded as bodies that are connected to natural bodies of water, which together constitute the regional managed, eco-engineered water resources systems. The number and variety of uses of artificial bodies of water require effective management, constant monitoring, and provisions for safe exploitation. Within the Aral Sea basin there are a large number of reservoirs, collection and drainage channels, and catch basins. The degree of regulated flow in the Syr Darya river basin is 1.17, meaning the reservoir volume exceeds the guaranteed volume of surface runoff, however, in the Amu Darya river basin this index is 0.78.

**Table 3.1**  
The degree of streamflow control in the Amu Darya and Syr Darya river basins

Source: Research and Information Centre of the Interstate Commission for Water Coordination in Central Asia

Country	Amu Darya river basin				Syr Darya river basin			
	Number of reservoirs	Reservoir volume (million m <sup>3</sup> )		Degree of control	Number of reservoirs	Reservoir volume (million m <sup>3</sup> )		Degree of control
		full	useful			full	useful	
Kazakhstan	-	-	-	-	21	10,075	8,867	-
Kyrgyzstan	-	-	-	-	8	20,519	14,450	-
Tajikistan	12	25,287	13,970	-	4	4,413	2,813	-
Turkmenistan	19	7,960	7,006	-	-	-	-	-
Uzbekistan	32	15,364	11,588	-	26	6,352	5,511	-
Total	63	48,611	32,564	0.78	59	41,359	31,641	1.17

The streamflow of Syr Darya's main tributaries – the Naryn, Chirchiq and the Kara Darya rivers – is regulated by the Toktogul, Charvak and the Andijan reservoirs, whereas the Kairakum and Shardary reservoirs are at the Syr Daria itself. The main regulator of the Syr Darya streamflow is the Toktogul reservoir, which has been regulating the flow of the Naryn for many years and compensating for the available water supply to the lower Syr Darya. The Amu Darya is regulated by two channel reservoirs on the Vakhsh River (the Nurek and Baipazin) and one on the Amu Darya (the Tuyamuyun) along with a number of internal off-stream reservoirs on the canals (four on the Karakum, one on the Karshin, two on the Amu-Bukhar) with a total volume of more than 6 km<sup>3</sup>.

One of the peculiarities of irrigated farming in Central Asia, as seen in the example of the Turkmen Altyn Asyr Lake (Golden Age), is the formation of collector and drainage waters, and return and seepage waters; this water makes up a third of the water that is collected for irrigation. This water is allocated beyond irrigation sites and becomes source water for irrigation or goes into internal non-drained depressions, forming surface irrigation returns. The combined total of this water was near the water input for the Aral Sea before it shrank. The surface irrigation return waters on even land

are nearing the drying out flood plains and the delta lakes of the Syr Darya and Amu Darya.

The Altyn Acyr Lake (Golden Age) has a capacity of 132 km<sup>3</sup> and a surface area of 3,460 km<sup>2</sup> and is established in the Kara-Shor natural basin. The construction period was from 2000-2009 and filling began in 2009.

Drainage water from irrigation projects feeds into the Turkmen lake via two trunk collectors: the main collector and the Dashoguz inlet. The length of the main collector is 720 km and it has a discharge capacity of 240 m<sup>3</sup>/s and starts from Lake Ulyshor, the receiving point of drain water from the main left bank collector. The Dashoguz inlet (383.8 km) is rated to discharge 210 m<sup>3</sup>/s and begins at the 57<sup>th</sup> km of the lake collector.

These collectors should bring the Turkmen lake a total inflow of 10 km<sup>3</sup> in collector-drainage water a year, which will, according to Turkmen specialists:

- stop the discharge of collector-drainage water into the Amu Darya from the left bank and eventually stop the discharge of collector-drainage water from Turkmenistan and Uzbekistan altogether and reduce the salinity in the middle and lower reaches of the river from 1.5 g/l to its previous level of 0.9 g/l;
- improve the sanitary conditions of drinking and household water supplies for the population living in the lower reaches of the Amu Darya; and
- restore the meliorative conditions of 450,000 ha of drowned and marsh lands.

### **3.2. Transnational Use of Transboundary Rivers: the Middle Syr Darya Case**

Use of the Syr Darya as an example shows the complex hydrological and climatic streamflow conditions that must be strategically considered on a daily basis when working with and coordinating the reservoirs' operating regimes.

The build-up of floodwaters during a freshet is completely dependent on the altitude of the river basin's watershed. Thus, the period of precipitation accumulation in the form of snow in the high mountain regions occurs between September and April and in the lower zones between November and March. The melting temperature is distributed from the bottom up and the timing of the start of the freshets beginning is completely dependent on this factor. The watershed at 2000 m begins flooding between the 10<sup>th</sup> and 20<sup>th</sup> of March whereas rivers with watershed of 3000 m start between the 10<sup>th</sup> and 20<sup>th</sup> of April. The Syr Darya basin has a wide range of altitudes and therefore areas of simultaneous melting are made up of only a few parts of the total watershed area. The peak discharge of meltwater forms when

an area of simultaneous melting at a medium intensity achieves the highest possible value. The intensity of rainfall plays a significant role in forming the peak discharge in low-lying watersheds, but the total volume of this runoff is not of crucial significance.

In the Syr Darya basin, the amount of frozen precipitation that falls during the cold periods and its subsequent melting in the spring is particularly significant in terms of volume and flood peaks. First, the peak levels occur at the Kokbulak gauging station (GS), and then in the Kara Darya River at the Kampyr-Ravat GS. Furthermore, they almost simultaneously pass through the Ak-Dzhar GS on the Syr Darya and at the Khodzhikent GS on the Chirchik River. They are finally observed in their final passage on the Naryn River at the Toktogul GS, where the peak occurs on average twenty days later than at the Kokbulak GS. By October the reservoir drawdowns should be completed in order to ensure a controlled prefreshet drawdown before filling the reservoir in the winter, keeping in mind the limited capacity of the riverbed downstream. With the onset of freezing temperatures, ice appears on the Syr Darya: first, young shore ice and frazil, followed by fixed ice cover. Ice cover is usually preceded by ice drifts. From the mouth to the Tyumen-Aryk GS, there is consistent ice coverage every year. Higher up the ice coverage is inconsistent from the Tyumen-Aryk GS to the Kok-Bulak GS. The first ice formations appear in November and end in March or early April. The number of days ice is present is on average between 90 and 131 with ice coverage lasting from 60 to 110 days. Towards the end of winter, the ice thickness is on average 60-70 cm. With the onset of the fixed ice cover, the water level of the Syr Darya rises and remains high until the ice breaks. The highest levels in winter are usually observed on the first or the last day of the ice coverage. The relationship between the highest summer and winter levels may differ: one year the winter levels may be higher than summer levels, while another year could, on the contrary, have higher summer levels than winter. The more often the highest winter levels exceed the highest summer levels, the closer the gauging station is located to the mouth. The water levels at the gauging station cannot be a reliable measurement of the ice jams or hanging ice dams as much depends on whether these formed above or below the gauging station and how close they are to the GS. The more water in the river during winter, the more flooding is observed and the more places there are where water could overflow from the river bed, accompanied by any adverse events.

Thus, the formation of freshets and the passage of the maximum flood discharges are observed at various times at various cross-sectional areas of the Syr Darya. The first maximum reaches the Shardara dam reservoir and the last one to occur is on the Naryn River at the Toktogul GS. Reported circumstances and the river regime determine the possibility of the high floodwaters passing through the reservoir located above Shardara at normal water levels.

Regulations for the Shardara reservoir, taking into account the Kairakum hydropower complex located upstream, are based on a noticeably higher flood discharge regime through the reservoir. The main points of these terms are:

- Filling in April and May should be as close as possible to the upper firm yield limit;
- The maximum possible amount of water should be maintained in the reservoirs until August in order to achieve an adequate, reliable output and the energy efficiency of the hydropower system during the vegetation period;
- Reservoir drawdown should be complete by October in order to ensure a controlled prefreshet drawdown before filling the reservoir in winter, keeping in mind the limited capacity of the riverbed downstream.

Given the peculiarities of the Syr Darya, the Shardara reservoir and the Arnasai Depression play an important role in regionally important flood prevention. The amount of surcharge in water levels over the HWL (highest water level) in the Kairakkum, Toktogul and Andijan reservoirs insignificant and they do not allow for significant flood peak reduction. The amount of acceptable surcharge (flood capacity) in the Toktogul reservoir is  $0.8 \text{ km}^3$ , in the Andijan –  $0.08 \text{ km}^3$ , and in the Kairakkum reservoir –  $0.8 \text{ km}^3$ . Thus, the entire flood runoff from the higher reservoirs is taken in by the Shardara reservoir in conjunction with the Arnasai Depression, thereby assuring safe passage for the floodwaters in the upper, middle, and also the lower reaches of the Syr Darya.

Construction of the Shardara reservoir in the middle reaches of the Syr Darya was completed in 1964 and it was filled from 1965 to 1968. The major purpose of this reservoir is to prevent the flooding and inundation of populated areas, interstate railways, and other objects of regional and national economic significance that arises from the summer freshets and the winter hanging dams. Winter runoff accumulates in the reservoir and is re-regulated in the summer period for irrigation needs, generating power along the way. The Shardara waterworks facilities include:

- HPP with an installed capacity of 100 MW and lower discharges with a discharge capacity of  $1850 \text{ m}^3/\text{s}$ ;
- Arnasai spillway for emergency floodwater discharge with a designed outflow of  $2100 \text{ m}^3/\text{s}$ ; and the
- Kyzyl Kum regulator with a designed outflow of  $200 \text{ m}^3/\text{s}$ .

The total reservoir volume is  $5.7 \text{ km}^3$ , of which  $4.7 \text{ km}^3$  is useable, and it has a length of over 80 km, an average width of 15 km, and an average

depth of 6.3 m with a maximum depth of 22 m near the dam. At the normal headwater level (NHL) of 252.5 m, the water area of the reservoir is 900 km<sup>2</sup>. The reservoir is filled in the autumn-winter period and is drawn from between April and August. The lowest water levels occur in October with the highest in March (reaching the designed levels). The long-term amplitude of water level fluctuates up to 8 m with an average of 5.4 m. Total discharge capacity of the Shardara hydropower plant's spillways is 3950 m<sup>3</sup>/s. The discharge capacity of the river's lower reaches is very limited: in the Kyzylorda region, it does not exceed 1,500-1,800 m<sup>3</sup>/s and the Kazalinsk region 750 m<sup>3</sup>/s. Releasing short-term catastrophic discharges is possible in the spring-summer period; due to the ice conditions in the winter, discharges in the lower reaches should not exceed 400 m<sup>3</sup>/s. For this reason, the discharge from the Shardara reservoir is limited by the designated discharge capacities for each stretch of the river. In the winter months when frazil and ice move down the river and create ice jams, the discharge capacity of the river bed falls significantly. This is most noticeable in the lower reaches below Kazalinsk where the climatic conditions are more severe than the rest of the basin. According to the regulations of exploitation from the Shardara reservoir, the maximum rate of discharge was established for a strictly limited timeframe (spring-summer period). The rest of the flood discharge should be flushed into the Arnasai Depression.

In the western part of the reservoir, above the Shardara dam cross-section, there is a Depression with an exit to the Arnasai. In the most constricted part there is a second dam 2.1 km long with an emergency spillway into the Arnasai Depression. The dam, which separates the Shardara reservoir from the Arnasai, is one metre lower than the main dam, which reduces the likelihood of catastrophic events at the hydropower plant in the event that the maximum floodwaters are released.

In the project design, it was also taken into consideration that at the time in the Arnasai region there were no populated areas or anything of any economic importance, which lessened any possible economic damage if water was discharged from the Arnasai hydropower plant or in an emergency situation.

Justification for the decision to combat the possibility of catastrophic floods on the Syr Darya, which was based on the operation of the Shardara hydropower plant together with Arnasai, was evidenced in 1969 when an exceptionally high amount of water accumulated for an extended amount of time, leading to the maximum flood discharge. The overabundant amount of water was a result of a combination of a number of natural and climactic factors: the accumulation of heavy precipitation during the winter followed by an intensive melting from the behaviour of the region's temperature. The flood discharge exceeded the discharge capacity of the hydropower plant's

spillway and it became necessary to discharge floodwaters into the Arnasai Depression from April to May and from November to December 1969, reaching 24.6 km<sup>3</sup> with water levels reaching the 239.3 m mark.

1969	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Inflow	152	165	280	2,410	3,140	3,760	2,390	875	547	429	376	286
Discharge into the Arnasai				1,728	1,528	1,920	411				617	800

**Table 3.2**

The water inflow to the Shardara reservoir in 1969 according to statistics from the nearby Chinaz-Syr Darya GS and water discharge into the Arnasai (m<sup>3</sup>/s)

Source: Sarsembekov et al., 2004: 72

The presence of regulated reservoirs like the Kairakkum and Shardara (with flood gates into the Arnasai Depression) prevented high river floods and thereby prevented huge economic losses in the region. The Shardara reservoir eliminates the winter floods if the tail water flow rate is kept low enough. When large discharges are released from the reservoir, there is a risk of flooding. Therefore, emergency winter discharges into the lower reaches were not foreseen on account of the extreme consequences for the population or economics assets. The reservoir's winter regime is designed for the accumulation of water. Flood control measures were proposed based only on spring-summer flooding and the only design solution (without no alternative) that was established in the rules of exploitation for the Naryn-Syr Darya cascade is to discharge into the Arnasai Depression.

The sluices that were subsequently built in the Arnasai Depression (2003) in the immediate vicinity of the Shardara reservoir emergency spillway did not save it from a similar emergency discharge. The probability of a catastrophic flood repeating on the Syr Darya similar to the one in 1969 remains quite high. Even in years with normal water level, in the winter months, the frazil and ice on the Syr Darya create intensive hanging dams and the discharge capacity of the riverbed falls sharply. This is most notable in the lowest reaches of the river where the climatic conditions are more severe than in the rest of the basin.

Due to the unresolved compliance issues of the Naryn – Syr Darya multireservoir system's winter operating regime, it was necessary that Kazakhstan build the Koksaray Reservoir to prevent the flooding of populated areas and economic assets during the winter. It is located on the Syr Darya, 160 km downstream from the Shardara reservoir, and acts as a counter regulator to it, seasonally regulating the flow.

The off-stream reservoir has a volume of 3 km<sup>3</sup> and a water surface area of 467.45 km<sup>2</sup>. The dam length is 44.7 km with an average height of 7.7 m and is designed to discharge up to 2,300 m<sup>3</sup>/s. Inlet (16 km) and outlet (10.2 km) channels have a discharge capacity of 500 m<sup>3</sup>/s. Construction of the water system, which begun in 2008 and finished in 2011, cost more than \$300 million.



**Figure 3.1**  
Headworks of the  
Koksaray Counter  
Regulator

*Source:* Executive  
Committee of the  
International Fund for  
Saving the Aral Sea

### Aidarkul–Arnasai Lake System

The Arnasai lake system is one of the pools designed to collect drainage and floodwaters in the irrigation farming area in the middle reach of the Syr Darya. The lake is situated in the Jizzakh Province of Uzbekistan in the middle reach of the Syr Darya. Aidar Lake is one of the largest basins in this system and extends along the foothills of the Nurata range for more than 130 km before passing on into the Tuzkan river basin. Southwest of the Shardara reservoir, the East Arnasai Lake links in, stretching almost 70 km as one of the main water collectors for the Golodnaya Steppe. The initial mode of the Arnasai Lakes as an irrigational/discharge pond was a result of water intake from the Central Golodnaya Steppe Collector (1957), which transferred water from the Sardoba depression into the Eastern Arnasai. Beginning operation in 1965, the Shardara reservoir together with the Arnasai hydropower station has a discharge capacity of 2,100 m<sup>3</sup>/s and allows for the regulation of water and salt regimes in the Arnasai Lakes. The increased flow of collector and drainage waters for irrigation projects and discharges from the Shardara reservoir in the second half of the 1960s increased the level of the East Arnasai Lakes. They started overflowing and the excess drainage water went into the Aidar basin. In 1969 there was a catastrophic surplus of water and more than 21 km<sup>3</sup> of water was discharged from the Shardara reservoir into the Arnasai Lake, the result of which led to the East Arnasai Lake, the Aidar river basin and Tuzkan Lake uniting and

forming a single lake system with a volume of over 22 km<sup>3</sup> and an area of over 2,500 km<sup>2</sup>. It formed an ecosystem of regional significance, becoming a nesting place and habitat for many species of birds and animals.

During the period of the sustainable and consistent working mode of the Naryn-Syr Darya cascade HPP with reservoir, that is, until 1993, fresh water discharges from the Shardara reservoir were limited and insufficient for desalination of the saline collector and drainage water and for maintaining lake levels. From 1993, the Central Asian countries disrupted the previously established operating mode of the reservoirs. The winter discharges exceeded the irrigation volumes and for the safety for the lower-lying areas, some of the incoming water was discharged from the Shardara reservoir into the Annasai depression. In 1994, more than 9 km<sup>3</sup> was discharged. The total volume of fresh water discharges from 1993-2005 was more than 38 km<sup>3</sup>. The increase in discharges led to the Annasai Lake System becoming the third lake in a basin of two rivers by 2005 (for comparison: the South Aral Sea's volume is 109 km<sup>3</sup> and Sarygamysh Lake is 46 km<sup>3</sup>), having reached its maximum volume of 44.19 km<sup>3</sup>.

The ecosystem of Aidarkul Lake and the surrounding territory covers a total area of 851,500 ha – the site of the sustainable development of the Nuratau-Kyzylkum Biosphere Reserve, in which Tuzkan Lake is included.

The Annasai Lake System is used for breeding, passage and wintering by many rare and endangered species of birds (between 60,000 and 120,000 birds during the winter) listed in the IUCN Red List and the Red List of Uzbekistan (the Dalmatian and Great White pelicans, the Pygmy Cormorant, the Little Egret, the Mute Swan, the Ferruginous Duck, etc.). It is also used for irrigation, fish farming, and hunting. At the end of 2008 the Aidar-Annasai Lake System was recognised as the wetlands of international importance receiving the status of the Ramsar site. The integrated development of the Annasai lakes is connected with the creation of large fisheries and the development of irrigated agriculture. In 2005, there were 44.3 km<sup>3</sup> of water in Aidarkul with a lake area of about 3,000 km<sup>2</sup>, a length of 250 km, and a width of 15 km. Within the lakes many species of game fish are found, including carp, perch, bream, catfish, asp, sabrefish, and snakehead whose annual catch totals between 760 and 2,000 tonnes.

The Annasai Lake System's regime is determined by the flow of collector and drainage waters discharged from the Shardara reservoir, atmospheric

**Table 3.3**  
Key Figures of the  
Annasai Lake System  
and Reservoir

Source: RU, 2008:  
44

Name of Lake	River Basin	Area (km <sup>2</sup> )	Volume (as of 01.01.2007, million m <sup>3</sup> )	Volume (as of 01.01.2008, million m <sup>3</sup> )
Annasai Lake System	Syr Darya	3,508	–	40,360
Annasai Reservoir	Syr Darya	140	393	468

precipitation, and evaporation. To further create and develop the conditions for fish farming, the lake system underwent reconstruction. In 2003, Uzbekistan completed the construction of several priority objects in the Arnasai complex, among them: a reservoir (600 m<sup>3</sup>), two dams, a dyke, feeder and pumping channels with facilities, two pumping stations, power lines, a substation, and other facilities set up to control the operation of the pumping stations at the Arnasai complex with a home station in Dustlik and a reservoir management station in the village of Zolotoi Most in the Arnasai region of the Jizzakh Province. The new reservoir provides irrigation water to 37,000 ha in the Mirzachul and Arnasai regions of Jizzakh Province.

Water has not been discharged from the Shardara reservoir into the Arnasai since March 2006. With the termination of releases from the reservoir, water levels in the lakes will decrease by 0.4-0.6 m annually for the first three years. Evaporation is one of the main output components for balance (1,250 mm on average a year), so the absence of river flow will increase water salinity (annual average is 300 mg/l). The volume of collector and drainage inflow varies from year to year between 1.8-2.4 km<sup>3</sup>/year. With the decreasing water levels in the Arnasai lake system, the process of secondary pollution has been activated as there are accumulated pollutants and toxic substances in the sediment from the collector and drainage waters. The absence of more than 4 km<sup>3</sup> leads to a rise in the Arnasai lake system's water level of not less than 0.5m (up to 250 m) and flooding of up to 200 km<sup>2</sup>. The optimal solution could be to maintain the water levels of the Arnasai lake system up to 245 m. Taking into account its special place as a vital natural and economic object, the Uzbek Cabinet of Ministers adopted the "Programme of Action for the Stability of the Ecological Environment and Efficient Use of the Aidar-Arnasai Lake System in Uzbekistan for the period of 2008-2012".

The design study carried out in the 1970s noted that the creation of a reservoir in the Arnasai depression for discharged water, including collector and drainage waters was not economically viable and had huge costs associated with it.

Studies conducted by the Water Institute of the Uzbek Academy of Science confirmed this suggestion and revealed the following properties of the hydrochemical and hydrobiological characteristics of this lake system (Chembarisov and Shamsiyev, 2008: 24-26). The annual Shardara reservoir discharges and collector runoff dilute the lake water, forming an area of low salinity (2-3.5 g/l) at the confluence zone. An analysis of all hydrochemical water indices from the Aidar-Arnasai Lake System (AALS) revealed that the concentration of 7-8 compounds of various hazard classes have exceeded their maximum contamination levels in recent years. According to the data and the State Standard of drinking water, water from the AALS cannot be used for household or drinking purposes in its natural state. Lake system

water (especially in the undrained bays, where salinity is 8-10 g/l) is not suitable for the irrigation of cotton, melons, or other crops. Use for irrigation purposes can lead to overall soil salinity and chlorination as well as sodium and magnesium alkalinity. In dry years, a limited amount of lake water may be used to irrigate salt-resistant crops. The ecological conditions of the AALS are also noticeably impaired as the content of several compounds in the water exceeds the maximum contamination levels. And as for the economic uses of the AALS, it is preferred that carp, silver carp, perch, roach, and asp are bred in strict quality controlled water that assures flowage. The water is completely suitable for irrigation in areas that receive discharges from the Shardara reservoir.

After the Aral Sea, the largest body of water in the region is the complex of reservoirs formed in the middle reaches of the Syr Darya including the AALS (Uzbekistan) and the Shardara and Koksaray reservoirs (Kazakhstan). The length of the Shardara-Arnasai-Aidar bodies of water is more than 240 km with a width of up to 50 km. The total water volume is more than 47 km<sup>3</sup>, which exceeds the storage capacity of all the reservoirs in Central Asia (40 km<sup>3</sup>). The water surface is more than 4,200 km<sup>2</sup>. Total evaporation is more than 1.5 km<sup>3</sup> annually (other statistics record 4+ km<sup>3</sup> annually) (Klimenko, 2009). The creation of a large number of reservoirs covering a significant water area in the middle reaches of the Syr Darya has had a significant effect on the transformation of the historical weather and agro-climatic conditions. As the results of the agro-meteorological observations show, the reservoir system significantly affects the weather of the Samarkand, Jizzakh, Syr Darya and Tashkent Provinces, especially the western winds (up to 90%). The AALS and the Shardara and Koksaray reservoirs create special weather conditions for distances of up to 150-200 km. In the spring-summer periods, strong convective cloud systems cover large areas. These are caused by the interconnected energy processes in all the areas of convective instability. The consequences of this are hard to predict, but they include heavy wind, lightning, hail, and showers, the result of which is devastating mudslides across a vast territory. In the spring-summer period, the development of convective clouds over the water reservoir system bring 15-50 mm of precipitation and squally gusts of wind from 15-30 m/s. In some cases, cyclones form over the system of reservoirs with the corresponding negative effects of heavy rains and strong winds.

The negative impact on the reservoirs manifest themselves in the increase of hail precipitation (nearly 60 cases) and an increase in the number of cloudburst floods. In the next 10-15 years, there could be possible increases in rain precipitation from 8-12% to 15-25%, resulting in an increase in the number of floods and the strength of cloudburst activity. In particular, the heavy spring-summer rains that were previously not characteristic of this

region have forced cotton growers to reseed. Rising air temperatures will lead to a shift in the earlier than usual spring river floods, which negatively affect agricultural production. The negative impact of the reservoirs also affects the increase of the dustiness of the air and the transfer of salts across the Samarkand, Jizzakh, Syr Darya and Tashkent provinces. The reservoirs' influence is causing the intensity of salinity in the soil to intensify, especially in the shallow groundwater level, which contributes to the growth of salinity and land degradation and negatively affects crop yields. Cloud formation caused by the influence of the water system decreases the number of sunny days by 30%, which leads to negative consequences for agricultural production. The reduction in thermal resources during the vegetation season as the sum of the average daily temperature ranges between 200-500°C, which is 5-20% below the norm and results in lower crop yields (Chub, Myakov, Klimov, 2012).

One of the main areas for cooperation between Central Asian states should be the development of modern and effective methods of treating and reusing collector and drainage water from irrigated land, and improving treatment technology for industrial and municipal water. Taken together, these determine the stability of the sustainability of the river's ecosystem and water safety. Concrete actions in the areas of improving the quality of transboundary river water quality and a constant reduction in the discharge of untreated water into rivers should be carried out by each country in the region in order to preserve the Aral Sea.

Tackling these problems is of particular importance given that the quality and safety of the water in the transboundary rivers in Central Asia are also threatened by mining waste and degradation. The water quality of the Amu Darya and Syr Darya is one of the priority issues for interstate cooperation: the different parties should take practical measures to avoid and prevent the deterioration of water quality in the river basins. The new ecosystem of the Aral Sea should be based on the principles of sound water management and water quality and safety.

One of the bodies of water – the Lesser Sea in the northern part of the Aral Sea – was constructed by Kazakhstan as part of an agreement signed by the Central Asian states called the “Aral Sea Basin Programme”. The higher the levels that are stabilised in the main separated reservoirs of the Aral Sea, the lower will be negative socio-economic and ecological consequences from the further shrinking of the sea, which has been broken up into parts and has seen decreased residual water levels. This result can be achieved by a transition to a management regime for these bodies of water that requires reconstruction of the sea and ensures a balanced flow into the reservoirs. The area of the Aral Sea, or more exact, its reservoirs, should be developed to a size where the surface evaporation is less than the total river inflow and precipitation

that falls on the basin (Bortnik et al., 1991: 62-68). By providing a guaranteed flow of water from the Amu Darya and the Syr Darya and stabilising the irrigated lands, it may be possible to preserve or restore the interconnected bodies of water of the Aral Sea, which would create opportunities to improve the geoecological conditions of the surrounding Sub-Aral region. The area of irrigated land in the Amu Darya basin should be stabilised to a level of 3.8-4 million ha and the Syr Darya to 3.2-3.05 million ha and the Aral Sea basin as a whole to 7-7.15 million ha.

Kazakhstan has carried out its part in the implementation of the Aral Sea reconstruction project. Its northern section was separated from the main part of the Sea through the creation of a land dam with spillway dykes between the mainland peninsula and Kokaral Island. The construction of the Kokaral dyke was completed in 2005 and in so doing formed a reservoir with a volume of 27 km<sup>3</sup> and a surface area of 3,300 km<sup>2</sup>. Before the water started collecting, the water volume in the northern part and the surface area were 7 km<sup>3</sup> and 478 km<sup>2</sup>, respectively, less than the amounts in the controlled reservoir.

Its northern section was separated from the main part of the Sea through the creation of a land dam with spillway dykes between the mainland peninsula and Kokaral Island. The construction of the Kokaral dyke completed in 2005 formed a reservoir, as was planned, with a volume of 27 km<sup>3</sup> with a surface area of 3,300 km<sup>2</sup>. Before water started collecting, the water volume in the northern part and the surface area were 7 km<sup>3</sup> and 478 km<sup>2</sup> less, respectively. The dam's spillway is used to discharge excess water from the Lesser Aral Sea and can ensure an absolute sustainable level of 42 m as well flow and salinity regimes in the newly-created reservoir. Contributing to the improvement of the Aral Sea region, the Lesser Aral will allow this part of the sea to be preserved in a reconstructed form, encourage the restoration of the fishing industry and prevent the wind transport of salt from the dry seabed.

In addition, the continued growth of irrigated land re-used to reap a second harvest is changing the volume and structure of regional water use substantially and, consequently, is also changing the magnitude of inflow to the Lesser and Greater Aral Seas, especially during dry periods. As a result, a Resolution for the preservation and reconstruction of the Aral Sea issued by the Central Committee of the Communist Party of the Soviet Union and the USSR Council of Ministers in 1988 is still relevant. In it, a section states that in order to restore the damaged ecological balance in the Aral Sea region, save the Aral Sea (with reduced water levels) as a natural object that has significant influence on the natural environment and climatic conditions in the region, and improve the sanitary and epidemiological environment, it is necessary to establish a guaranteed flow of river water into the deltas of the Amu Darya and Syr Darya Rivers and into the Aral Sea, beginning in

	Measuring unit	Quantity
<b>Dam:</b>		
Length of dam	km	13
Volume of dam	thousands m <sup>3</sup>	3,200
Crest level of dam	m (according to Baltic System of Heights)	44.5
Average Height	m	4
Width of dam crest	m	9
Upstream slope		1:48
Downstream slope		1:3
Maximum water height	m (according to Baltic System of Heights)	42
<b>Spillway:</b>		
Number of gates		9
Size of gates: length	m	5.5
Width	m	3.9
Maximum discharge capacity	m <sup>3</sup> /s	295

**Table 3.4**  
Main Indicators of the Northern Aral Dam and its Spillway

Source: Executive Committee of the International Fund for Saving the Aral Sea

1990 with a volume of at least 8.7 km<sup>3</sup>/year and increasing it in 1995 to 11 km<sup>3</sup>/year, in 2000 to 15-17 km<sup>3</sup>/year and by 2005 to 20-21 km<sup>3</sup>/year (including collector and drainage water). It should be noted that at the beginning of the mass construction of the drainage systems in the Aral Sea basin, provisions were made for excluding collector water discharge into rivers. In particular, this approach was the basis for justifying the decision that the salt levels in the Syr Darya at the Shardara reservoir dam Shardara should not exceed 1 g/l. It is necessary to return to the principle that collector and drainage water should not reach beyond water districts. The Aral Sea should not accumulate this water, nor receive toxic substances from the entire watershed (Kuznetsov, 1991: 85-87). The five Central Asian countries should work further on the development of modern and efficient methods for the treatment and reuse of collector and drainage water from irrigated areas and also improve the treatment technology used for industrial and city/household wastewater.

The practical steps Central Asian countries have taken in the areas of improving the water quality in the Amu Darya and Syr Darya Rivers and other transboundary rivers and consistently reducing the discharge of untreated waters into the Aral Sea river basin should be considered as national contributions by each country to the preservation of the Aral Sea. Preserving the Sea is of particular relevance taking into account that the quality and safety of the water in the Central Asian transboundary rivers is also exposed to hazardous waste threats from mining and land degradation.

The combination of these factors determines the sustainability of the rivers' ecosystems and water security, stipulating the need for integrated water resource management at both national and regional levels.

Water quality for the Amu Darya and Syr Darya rivers is a priority issue for interstate cooperation and all parties should be taking practical measures to avoid and prevent the deterioration of water in the river basins. The new Aral Sea ecosystem should be formed on the principles of rational water management and the security of water quality in the Central Asian transboundary rivers.

The main tributaries of the Syr Darya – the Naryn, Chirchiq and the Kara Darya – are regulated by the Toktogul, Charvak and the Andijan reservoirs, with the Kairakum and Shardara reservoirs drawing from the Syr Darya. The main regulator of the Syr Darya is the Toktogul reservoir, which has been a flow regulator for the Naryn for many years and compensates the available water supply to the lower Syr Darya. Maintaining consistent and safe operating conditions of these and other reservoirs, the main canals, and large pumping stations connected to water intakes from the Amu Darya and Syr Darya is the basis for sustainable water management in the region. To this end, the CA countries need to develop by applying modern simulation methods and updated hydrology data and indicators of water quality to the operation of the reservoirs in a way that will comprehensively address water and energy, food commodities, and environmental problems over the long-term, taking into account changes in the availability of water, volume and the structure of water consumption.

However, the situation has become quite tense in terms of the parties following the operating regimes of the cascade of reservoirs in the Aral Sea basin. The main transboundary rivers flowing through the region are the Amu Darya and the Syr Darya, which differ sharply in the natural and climatic zones over their courses and in turn have a large impact on the reservoirs' operating regimes. This is especially true for the winter and spring periods of their operations. In the upper and partially in the middle reaches of the rivers where the water flows at a high velocity and the air temperature is above freezing, ice formation is usually not observed. Conditions are favourable for the construction of hydropower facilities. Ice formation is characteristic of the lower reaches of the rivers in Kazakhstan and Uzbekistan. The winters here are longer and more severe and the rivers are prone to freezing, forming hanging dams that cause sharp rises in water levels.

Despite these difficult operating conditions, the reservoirs' design conditions have been changed substantially in order to generate more electricity during winter. As a result of this winter output, the spring-summer riverflows increased. In order to accumulate water in the reservoir for energy purposes

during the summer, irrigation discharges are severely limited on the Syr Darya. The safety of dams and reservoir operations, including the Shardara as the closing structure for the Naryn-Syr Darya cascade of reservoirs, is dependent on the parties strictly adhering to the agreed upon mode of operation for the hydropower complex. The water management problems in the Syr Darya basin need to be solved taking into account the mutual influence of the transboundary bodies of water. Therefore, all hydraulic structure in the river basin should be considered elements of the interconnected water system. It should be kept in mind that every body of water has its own specific effects on water balance, water conditions, and the ecosystem of the river basin as a whole.

### **3.3. Shared Water Works and Hydropower Facilities in Central Asia**

Low levels of regional interaction and integrated trade and economic relations, unresolved water and energy issues, and sharp increases in the cost of fuel and foods imported from neighbouring countries are the main factors in the Central Asian nation's increased use of water resources for energy and irrigation purposes. Furthermore, the construction of new HPP reservoir and regulating structures, main canals and irrigation systems is often in violation of basin principles and does not comply with environmental requirements in terms of the maximum withdrawal of transboundary flows. These projects have no regard for the relationship between disposable water resources and their use in the short and long-term and do not notify their intent to neighbouring parties when erecting new structures on a transboundary river. Changes in the conditions in the role of reservoirs and other regulating structures on transboundary rivers complicate the solutions to energy, water, food, and environmental safety problems not just for the neighbouring countries but for the region as a whole.

New water power facilities and water works structures in the region are increasingly being developed on a bilateral basis. The participating party, as a rule, not only provides project financing and coordinates work on the facilities and structures, but upon completion of construction may also be entitled to joint operations for a specified period of time.

One of the first joint facilities in Central Asia was the Iran-Turkmenistan Friendship (Hydropower) Dam on the boundary Tejen/Hariroud River. Construction began in 2000 on a parity basis with Iran and was finished in 2004. The hydropower project cost \$168 million including the dam and a multi-purpose reservoir intended for irrigation, energy production, and flood control. The dam's height is 78 m and the reservoir's capacity is 1,25 billion m<sup>3</sup>. The hydropower plant has a total capacity of 14 MW (four turbines at 3.5 MW) and the reservoir provides irrigation water for 50,000 ha – 25,000 for each country.

Water from the Tejen-Hariroud river is divided between Turkmenistan and Iran equally through the Shirdepe (the Lion's Hill) water distribution unit located 25 km downstream from the Doosti (friendship) dam. The facilities in the complex include a sluice dam with a height of 2.8 m and a length of 100 m. On each side a double sluice has been built, each with a width of 3.5 m. One of these is on the Turkmen side of the dam and the other is on the Iranian side. The discharge capability of each is  $30 \text{ m}^3/\text{s}$ . Management and control of the water distribution at the HPP is carried out automatically with the use of modern control and measuring equipment. Information is supplied to control centres on each side and to a common control point located on the HPP.

The agreement between Turkmenistan and Iran about the joint use of the water resources from the Tejen-Hariroud River and the Doosti Reservoir with 410 million  $\text{m}^3$  for each government was signed in 2004 ([www.turkmenistan.ru](http://www.turkmenistan.ru)). Based on the principles of bilateral, good-neighbourly relations, non-interference in each other's internal politics, and mutual respect for mutual interests, the Agreement of Cooperation between the Government of the Islamic Republic of Iran and the Government of Turkmenistan is founded on the parity of each state with respect to all water and energy resources from the Friendship (Pulikhatusun) Dam and reservoir in the border areas of the Hariroud (Tejen) River.

In accordance with **Article 3** of the Agreement, the Parties agreed to provide equal funding for the construction of the reservoir dam and other structures and to pay 50% of the costs associated with the construction of the facilities. In the event of a request for support from Turkmenistan, and with consent from the Islamic Republic of Iran, Iran would provide the necessary capital investments and a way of representing this as a loan would be determined within two months by the economic and financial organisations of the two states taking into account accepted international law.

In order to finalise the project feasibility study and construction of the reservoir dam and associated hydraulic structures, **Article 4** of the Agreement states that the Parties shall jointly determine the area of construction and research. The procedure of transporting equipment and building materials into the area of construction will be regulated by the Simplified Rules of Crossing the Turkmen-Iranian Border in the Construction and Project Research Area in the Border Area of the Hariroud (Tejen) River, signed in Ashgabat on December 20, 1993 (30.09.1373 of the year of Hegira).

**Article 5** provides that each Party will independently carry out works related to the operation, repair and maintenance of all facilities, reservoir equipment and the power station located on its territory and will not perform any work that may cause injury to or damage the hydraulic structures or their mechanisms. If necessary, the implementation of joint work to strengthen the dams, water development facilities, reservoirs, discharge water and so on will

be carried out by mutual agreement of the Parties. All of the above-related expenses will be paid by the Parties in equal amounts, and settlement will be carried out at the end of every solar Hegira year.

It was determined that the Parties, in accordance with **Article 6**, could, by mutual agreement, jointly carry out general and overhaul repairs of facilities and technical equipment on an equal footing to provide reciprocal services. By mutual agreement, as noted in **Article 7**, if one of the parties fails to provide their portion of the expenses as specified in Article 5 of the Agreement, the other party may provide the abovementioned expenses and in exchange use water and energy resources equal to the costs expended. The cost of water and energy resources will be determined by specialists from both sides.

The Friendship Dam and its facilities, according to **Article 8**, are the joint property of Turkmenistan and Iran and may not be divested by either parties and also may not be transferred to an individual, legal entity or third country.

In view of each party's parity regarding the use of water and energy resources from the Hariroud (Tejen) River and the associated facilities in the area of the Friendship Dam, **Article 9** states that the parties have agreed that all water from the Hariroud (Tejen) River in the retaining dam (both regulated and discharged) is divided into two equal shares. The amount of useless discharged water used by the parties below the Pulikhatun Bridge does not reduce the water that either party has accumulated in the reservoir. With prior agreement, the parties may attempt to utilise the "useless" discharge water by the construction of relevant structures.

**Article 10** envisages that citizens of either party who are engaged in the operations and management of the water development facility, will out of necessity be given the right to enter and remain in the either country's territory. Related to this matter, in **Article 11**, the nations agreed that construction of the Friendship Dam and its related facilities would not change the state borders. Following the completion of the construction of the dam and its reservoirs, the existing border will be demarcated on the surface of the water and will be an official Iranian-Turkmen state border.

According to **Article 12**, the parties agreed not to carry out work that could lead to contamination of the reservoir and the environment by the dumping of polluted water or any other substance and have also agreed to follow all laws on environmental protection. In the event of reservoir and/or environmental contamination by one of the parties, that party is under obligation to take measures to eliminate the contamination and compensate for damages.

Tajikistan has great hydropower potential and is ranked eighth in the world after China, Russia, USA, Brazil, Congo, India and Canada in the availability

of these resources (527 billion kWh per year, of which 88 billion kWh per year are suitable for development). The hydropower potential of the Vakhsh and the Panj Rivers is 48% and 23.2%, respectively, or 71.2% of Tajikistan's water resources. The Kafirnigan, Zerafshan, Bartang and Gunt river basins (together totalling 21.76% of the country's hydropower resources) hold the bulk of the volume (93%) of Tajikistan's hydropower potential and a new HPP is planned for this area.

The HPP operating mode and the production of electricity are determined by the hydrological characteristics of the river (seasonal fluctuations), in turn accounting for the fluctuations in electricity production throughout the year. The generating capacity of thermal plants does not provide adequate compensation for the country's electricity needs during the periods when HPP generation is low.

The development of Tajikistan's water power resources is mainly tied to the Vakhsh river basin where a cascade HPP was planned back in the 1950s. The following hydropower plants were constructed: Roghun, Nurek, Baipaza, Sangtuda-1 and Sangtuda-2, Vakhsh-Golovnoi, Perepad, and Tsentralny HPP. The largest in the cascade is the Nurek HPP with an output of 3,000 MW. Construction of the HPP and nine aggregates and a total annual electricity output of 11.4 billion kWh began in 1961 and was completed in 1979. The dam's height is 300 m with a full reservoir volume of 10.5 km<sup>3</sup>, a useful volume of 4.5 km<sup>3</sup>, and a surface area of 98 km<sup>2</sup>.

The Nurek HPP and reservoir, being the backbone of the Vakhsh HPP cascade and all of Tajikistan's energy system, also plays a key role in the interstate regulation of the use of water resources in the Amu Darya basin.

All major hydropower facilities in Tajikistan were built during the existence of the USSR and with its collapse, all further hydropower development in the country came to a halt. As a result of physical aging and the obsolescence of the highly deteriorated HPP equipment and network infrastructure and a decrease in funding for repair and modernisation, there has been an annual reduction in the production of electricity and technical losses of more than 2-2.7 billion kWh. This and the unstable parallel operation of the energy systems of the countries in the region cause a deficit in the amount of electricity, especially in winter. As the population grows, the energy deficit will increase and new generating capacities are being planned to eliminate this problem.

The plans for the restoration of Tajikistan's hydropower dates back to 2004 when an agreement was signed between Russia, Tajikistan and Iran on the construction of the Sangtuda HPP-1 and Sangtuda HPP-2.

The development of the Sangtuda HPP-1 project and the construction of preliminary objects (roads, electricity and telephone lines, etc.) were

carried out simultaneously. Because the USSR had collapsed, the earlier construction work on the facilities had been halted (at that time about 13% of the work had been completed). In October 2004, an agreement was signed between Russia and Tajikistan covering the procedures and conditions of equity participation from Russia in the construction of Sangtuda HPP-1 and work resumed. In February 2005, Russian-Tajik Sangtuda HPP-1 JSC was founded. Through charter capital, Russia owns 84.03% of the Open Joint Stock Company, and Tajikistan has the remaining 15.97% of the shares. The investment by Russia and its energy companies, mainly JSC Inter RAO UES, amounted to more than 16 billion roubles (more than \$500 million). The station went online on July 31, 2009.

Sangtuda HPP-1 is the largest investment project and the first joint hydropower facility with joint use and operation implemented by Russia in the CIS. This cooperation in the hydropower field is of great interest and the experience could be put into practice in the construction of hydropower and water energy systems by two or more countries in the region. It therefore seems appropriate to detail more about the organisation of the construction and operation of Sangtuda HPP-1.

The HPP is located on the Vakhsh River in the Dangara region of the Khatlon Province, 110 km south of Dushanbe. As the fifth step of the Vakhsh cascade of hydropower systems, this includes two of the largest HPP in Tajikistan: the Nurek (3,000 MW) and the Baipaza HPP (600 MW). The installed capacity is 670 MW, there are four hydro-aggregators at the plant, each with a rated capacity of 167.5 MW and not requiring repair for 25-40 years. The average annual power generation of the HPP is 2,733 TWh with 1.64 TWh in the summer (April – September) and 1.1 TWh in the winter (October – March). The total reservoir volume is 258 million m<sup>3</sup> of which 12 million m<sup>3</sup> is useable. The surface area is 9.75 km<sup>2</sup> and has a flood-control storage level of 571.5 m and a dead-storage elevation of 569.9 m. The rock-fill dam has a loam core and is 75 m high and 517 m in length.

Increasing the use of Tajikistan's water resources and economic potential by 3%, the Sangtuda HPP-1 provides about 15% of the country's total electricity generation and reduces the seasonal deficit by 30%, increasing the possibility of exporting electricity during the summer. Sangtuda HPP-1 was designed by the S.Y. Zhuk Hydroproject Institute and constructed by Russian and Tajik organisations.

The main activity of JSC Sangtuda HPP-1 (the operator of Sangtuda HPP-1) is the production of electricity. The structure and capacity of JSC Sangtuda HPP-1's managing body are determined by the Tajik law on Joint Stock Companies and the company's charter. The supreme management body of the JSC is the general shareholders meeting. Procedures for the preparation for and conducting of a general meeting are determined by the relevant provision.

The enterprise's general management activities, with the exception of solving problems within the competence of the general shareholders meeting, are carried out by the board of directors. The General Director has authority as the sole executive body of JSC Sangtuda HPP-1 dealing with matters concerning the company's current activities. The function of internal control over financial and economic activities is performed by the internal audit committee.

Tariffs for the generated electricity are set in accordance with an Agreement between the governments of Russia and Tajikistan on cooperation in the operation of Sangtuda HPP-1 dated July 30, 2009. In particular, Article 2 of the Agreement reads: "Beginning August 1, 2009, the Tajik side guarantees the purchase of energy at the bus bars produced at Sangtuda HPP-1 for the internal market at a tariff of \$0.0169 per 1 kWh net of VAT for 20 years. Starting January 1, 2010, the tariff for internal markets will increase annually by not less than 4% from the previous year's tariff". Article 3 of the Agreement caters for a scenario where changes in Tajikistan's legislation result in the recouping of investment in the construction of Sangtuda HPP-1 being likely to take more than 20 years, stating that Tajikistan shall purchase the electricity produced at Sangtuda HPP-1 in accordance with the increased tariff agreed on by the company and Tajikistan, thus allowing the investment to be recouped within 20 years from the date the station was brought online.

Electricity produced at HPP-1 is transferred, distributed and sold to end users, people and businesses, by the Open Joint Stock Holding Company Barki Tojik. Tariffs vary according to categories of customers. As at January 1, 2010, the cost of 1 kWh for individuals cost \$0.0206; for industrial and non-industrial users \$0.0487; and for state-financed organisations and utility companies \$0.0195.

**Sangtuda HPP-2** is also a joint hydropower facility. In accordance with an agreement between Tajikistan and Iran on construction of Sangtuda HPP-2 on the Vakhsh River (June, 2005), the Iranian capital input was \$180 million and the Tajik, \$40 million. Revenues from the HPP after being put into production will belong to Iran for the first 12.5 years. After this period, the facility will become the sole property of Tajikistan. The project contractor was Iranian company Farob. The construction of Sangtuda HPP-2 began early in 2006 and was completed at the end of 2011. The installed capacity of HPP-2 is 220 MW, producing 1 billion kWh annually. As the lower step of the Sangtuda power hub, the station works in parallel regime with the Sangtuda HPP-1 downstream from the Nurek reservoir. Collaboration allows for daily flow regulation and protection from the more intense winter load demands.

Tajik and Iranian cooperation is expanding in the hydropower field as Iran intends to participate in the construction of the Aini HPP with a capacity

of 130 MW and is considering financing the construction of the Nurabad HPP-1 and HPP-2, each with capacities of 350 MW. The cascade of Aini, Nurabad-1 and Nurabad-2 stations will be built on the Zarafshan River. China had expressed its willingness to build Nurabad HPP-1, however, they abandoned their plans in 2009 due to Uzbekistan's opposition to the construction of HPP on transboundary rivers, suggesting that it may have a negative effect on the conditions for its operation (Troitskiy, 2010).

Another major hydropower facility, not just for Tajikistan but for the entire region, is the Roghun HPP. The project was conceived by the Sredazgidroproekt Institute (Tashkent) and was approved by the State Construction Committee of the USSR in 1974. The Roghun HPP is an appurtenant station with a rock-fill dam with a height of 335 m, making it the highest in the world. The projected capacity is 3600 MW with an average annual production of 13.1 billion kWh. The HPP should have six radial turbines each with a capacity of 600 MW. The HPP dam forms a reservoir with a full volume of 13.3 km<sup>3</sup> and a useful volume of 10.3 km<sup>3</sup>, which will be used for energy and irrigation as well as long-term flow regulation.

The Roghun HPP facilities are as follows: rock-fill dam made from local materials is 335 m high; construction and operation tunnels; and an underground HPP building that includes a turbine room and room for transformers.

Construction preparations for the station began in 1976 with construction of the dam (the upstream cofferdam) starting in 1987. The Vakhsh was closed off on December 27, 1987. By 1993, the height of the constructed upper cofferdam had reached 40 m, 21 km of tunnels had been completed, and the majority of the work on the turbine room had been completed (70%) as well as on the transformer room (80%).

After the collapse of the USSR, construction on the HPP came to a halt and was only resumed in 2004 following the signing of an Agreement between Tajikistan and the Rusal company of Russia on the completion of the station. The Hidroproekt Institute (Moscow) prepared a feasibility study while Tajikistan carried out a number of works at the HPP site. However, the parties could not reach a consensus on the type and parameters of the dam and as a result the agreement was unilaterally cancelled in 2007. Thereafter, Tajikistan built the Roghun HPP itself. The closure of the Vakhsh River was planned for 2009, but it was delayed for technical and political reasons. In December 2010, work was completed on the first of the station tunnels. An Agreement was signed between Tajikistan and the World Bank in 2010 for an international examination of the Roghun HPP project and in February 2011, Swiss company Poyry Energy Ltd. was chosen to do the work.

Construction of the hydropower complex is scheduled to be carried out in several stages, with the capacity of the first phase being 400 MW with an average annual output of 5 billion kWh. The cost of construction is estimated at \$2.2 billion – the first stage costing \$590 million. The launch of the first stage of the Roghun HPP, which includes two hydro turbines with a total capacity of 400 MW, is scheduled for the end of 2012. A portion of the hydropower equipment, including the two hydroturbines produced by Kharkiv company Turboatom, was delivered in the early 1990s.

In the Concept document for the development of Tajikistan's fuel and energy industrial complex 2003-2015, the main goal is a balanced use of fuel, energy and water resources and to ensure a stable energy and fuel supply for the Republic. This includes the phased development of the country's fuel and energy sector. Among the main priorities for the development of Tajikistan's fuel and energy sector between 2003 and 2015, ensuring energy security for the Republic, is the construction and launch of a number of small HPP. The State Project Management Centre for the Electricity Sector was created for this purpose, and is responsible for coordinating the projects that are approved by the Long-Term Programme for the Construction of Small Power Stations from 2007-2020, regardless of the source of funding.

The Long-Term Programme for the Construction of Small Power Stations consists of three steps:

- Short-term phase (2009-2011) – 66 stations with a total installed capacity of 43.53 MW at an estimated cost of \$51.593 million;
- Mid-term phase (2012-2015) – 70 stations with a total installed capacity of 32.85 MW at an estimated cost of \$39.38 million;
- Long-term phase (2016-2020) – 53 stations with a total installed capacity of 26.801 MW at a cost of \$32.161 million.

The intention is that funding for this programme should be attracted from local and foreign investors. There are also some advantages to industrial enterprises in the construction of their own small HPP. Electricity produced by these will be cheaper than that bought from the power grid. The cost of electricity at a small, privately-owned HPP will not exceed the production cost. Experience from the construction of a small HPP in Tajikistan, shows that the unit cost of construction does not exceed \$1,100-1,200/MW.

The investment needs of all three programme phases are more than \$123 million and the means for their implementation are being attracted from international financial institutes. The Islamic Development Bank (IDB), the Asian Development Bank (ADB), the International Finance Corporation (IFC),

UNDP, and the Islamic Republic of Iran are financing the construction of 23 small HPPs.

Kyrgyzstan has similarly developed and is implementing a programme to build new large and small HPP, the highest priority of which are the Kambarata HPP-1 and the Kambarata HPP-2.

Name	Installed Capacity (MW)	Duration of Construction (years)	Planned Input Capacity			
			2010	2015	2020	2025
Kambarata HPP-1	1,900	2013–2023			475	1,425
Kambarata HPP-2	360	2007–2012	120	240		
Upper Naryn HPP-1, 2, 3	200	2012–2018			180	
Akbulun	200	2015–2019			200	
Kara Kechin TPP	1,200	2016–2025			1,200	
<b>Total</b>			120	240	2,055	1425

**Table 3.5**  
Planned HPP construction in Kyrgyzstan

Source: Kyrgyz Ministry of Energy

For Kambarata HPP-1, the volume of the reservoir is 4.650 million m<sup>3</sup>, the normal water surface elevation is 1,190 m, the installed capacity is 1,900 MW (4x475), and electricity production will be 5.088 million kWh annually. The approximate cost of construction is \$1.7 billion.

For Kambarata HPP-2, the normal water surface elevation is 955 m, the installed capacity is 360 MW (3x120), the reservoir volume is 70 million m<sup>3</sup>, and the electricity production will be 1.148 million kWh annually. The first hydro turbine of the Kambarata HPP-2 was brought online on August 30, 2010.

Name	Quantity	Capacity (MW)	Output (million kWh, annual)
Restoration of pre-existing small HPP	33	22	100
<b>Construction of new HPP:</b>			
on reservoirs	7	75	220
on river stations	92	178	1200

**Table 3.6**  
Development prospects for small HPP in Kyrgyzstan for 2010-2025

Source: Kyrgyz Ministry of Energy

The intended future sale of electricity by Kyrgyzstan and Tajikistan is directed at countries in South Asia. To accomplish this, in 2006 with assistance from the ADB, the CASAREM (Central Asia/South Asia Regional Electricity Market) programme for the development of a sub-regional electricity market was developed. The CASA-1000 project (Central Asia/South Asia) was selected as part of this programme, to export electricity produced in

the summer by active hydropower plants in Tajikistan and Kyrgyzstan to South Asia. The participants in the CASA-1000 project and the CASAREM programme are Afghanistan, Kyrgyzstan, Pakistan and Tajikistan.

The total cost, including incidentals and interest during construction is \$953 million. This also includes strengthening the internal transmission networks necessary for the CASA project and the preliminary ecology and social costs. It is expected that each country will allocate funds to finance the facilities located within their borders that are involved in the project. A breakdown of the costs per country looks as follows:

Afghanistan – \$309 million, Kyrgyzstan – \$196 million, Pakistan – \$197 million, and Tajikistan – \$251 million. As previously stated, the total project cost is \$953 million.

The World Bank is currently considering carrying out environmental, social, financial, economic, and poverty level impact assessments. After a thorough study of these aspects from all sides, the World Bank will only consider financing a part of the total investment, attracting other international financial institutes to this end. The Bank also intends to assist Kyrgyzstan in planning the country's financial stake in the project.

CASA-1000 provides for the creation of an electricity transmission system from Kyrgyzstan and Tajikistan to Afghanistan and Pakistan, allowing the first stage to export up to 1,000 MW with subsequent supply increases in these internal markets. The primary objective of the CASA-1000 project is the construction of an intersystem of power lines and proposes the construction of the following: 500 KW power lines stretching 477 km from Datka – Khujand, connecting Kyrgyzstan's and Tajikistan's power grids; 500 KW power lines stretching 350 km from Khujand – Roghun-Sangtuda, connecting the border of Kyrgyzstan and northern Tajikistan with central Tajikistan; 500 KW power lines stretching 750 km between Sangtuda – Kunduz – Puli-Khumri – Kabul – Peshawar, passing from Tajikistan into Pakistan through Afghanistan; and electric power substations in Datka, Khujand, Sangtuda, Kabul and Peshawar.

Under the CASAREM programme, the North-South (Tajikistan) high voltage 500 KW lines have been constructed and brought into service and construction is continuing on the high voltage 220 KW lines from Tajikistan – Afghanistan, with plans in place for the construction of high voltage 500 KW lines from Datka – Kemin – Almaty (Kyrgyzstan – Kazakhstan). A regional intersystem high voltage 220 KW line has already been realised from Sangtuda – Puli-Khumri (Tajikistan – Afghanistan) and includes the construction of 118 km of lines in Tajikistan from Sangtuda HPP-1 to the border and a further 156 km in Afghanistan. Tajikistan has already completed the laying of power lines, whereas work in

Afghanistan is still underway. The high voltage 500 KW lines from Datka – Kemin that stretch 410 km are scheduled to be completed in 2012-2013.

It is expected that the CASA-1000 project along with other projects like the CASAREM programme will intensify the electricity market in the region, especially during seasons when there is excess generating capacity in Tajikistan. Electricity can also be transmitted north through Kazakhstan to Russia. In October 2006 in Dushanbe, leaders from Afghanistan, Kyrgyzstan, Pakistan and Tajikistan signed a memorandum of understanding and confirmed their intention to construct combined power lines. As part of the implementation of the first phase of the CASAREM, the construction of vital infrastructure is planned for the transmission and distribution of electricity as well as the introduction of systems that can export between 1,000–1,300 MW into the countries of Central and South Asia. This is herein referred to as the CASA-1000.

It is further expected that a large part of the electricity will be imported into Pakistan with a relatively lower amount (up to 300 MW) into Afghanistan. In 2009, the ADB left the project and the World Bank committed itself to assisting in preparing a feasibility study for the construction of the power lines. Representatives of the CASAREM created an Intergovernmental Council (IC) based in Kabul. This council is responsible for reviewing the report of the feasibility study and, after approving its results, turning to the World Bank and Islamic Development Bank with a request for a loan (\$953 million). These feasibility studies do not provide a thorough study of the availability of regional water resources in the future, despite the obvious correlation of export relations between Kyrgyzstan and Tajikistan with the regulated operating regimes of HPP, which in turn, are linked to the irrigation needs of other, lower-lying riparian countries along the international watercourse.

Kazakhstan is also increasing the construction of medium and small sized HPP, mainly in the southeast part of the country. In 2011 construction was completed on the Moinak HPP on the Charyn River, which had begun in 1985. Due to a lack of funds, construction works on this facility were suspended in 1992 and only resumed again in 2005 following decrees issued by the Government of Kazakhstan on its Electricity Development Programme until 2030 (no. 384, April 9, 1999), Additional Measures for Hydropower Development in Kazakhstan (no. 161, February 22, 2005), and the Construction of the Moinak Hydropower Plant (no. 1143, November 21, 2005). The main goals of this project are to create a flexible source of electricity to address the power supply deficit faced by the southern areas of Kazakhstan and to cover peak demand periods (i.e. operate within the balanced electricity market). The project was

commissioned by JSC Moinak HPP and the main contractor was China International Water & Electric Corporation. The total project cost was more than \$360 million. Financing for the construction of the HPP was made possible by \$133 million from the Kazakhstan Development Bank and \$200 million from the China Development Bank. JSC Samryk-Energo put up \$28 million of its own funds.

Moinak HPP is located on the Charyn River 250 km east of Almaty. The Charyn River has great hydropower potential and a HPP cascade was planned here as far back as the 1970s. The Moinak HPP is the second and most powerful stage planned of the Charyn HPP cascade.

HPP	Normal Water Level (m)	Pressure (m, statistical)	HPP installed capacity (MW)	Electricity production (million kWh annually)
Bestyube	1,800	55	40	101
Moinak	1,745	503	300	1,020
Aktogai	1,210	206	125	485
Bestamak	1,004	89	50	205
Mointokai	900	68	40	166
Sartokai	795	40	25	95
Cascade total		959	580	2,072

**Table 3.7**  
Energy Performance  
of the planned HPP  
Cascade on the  
Charyn River

Source: Chokin et al.,  
1987: 214

The Moinak HPP uses hydropower resources from the Charyn River at its steepest drop between the 1745 – 1242 m mark ( $h = 503$  m). The HPP was designed and built as a derivational dam. The project capacity of the HPP is 300 MW with an annual production of 1.27 billion kWh. The HPP building is equipped with 2 Pelton hydro turbines, each with a capacity of 150 MW. The manufacturing, delivery and installation of these cost \$18 million each and was carried out by ANDRITZ of Austria. The generators were manufactured by Harbin Power Equipment of China.

Among the hydropower facilities include the following: a rock-fill dam with a height of 94 m, a reservoir, a derivation tunnel 9 km long, spillway structures, and a powerhouse. The HPP dam forms the Bestyube reservoir which floods an area of 10 km<sup>2</sup> and has a length of 16 km, a width of up to 0.5 km, a maximum depth of 90 m, a full capacity of 238 million m<sup>3</sup>, and a useful capacity of 198 million m<sup>3</sup>.

To increase its share of hydropower resources in the fuel and energy balance, Uzbekistan is planning to build a number of small and medium HPP with a total capacity of 937.6 MW in the medium-term. Uzbekistan's Ministry of Agriculture and Water Resources is consistently implementing a HPP facility construction project on its existing reservoirs. The following have been brought

into service: Ahangar HPP (42 MW) in Tashkent Province, the Gissar HPP (45 MW) in Kashkadarin Province, the Shakhimardan HPP (2.2 MW) on the Koxsu River in Ferghana Province and the Gulba HPP (6 MW) in Samarkand Province. With the completion of the second extension of the Tupolang GPS at Surxondaryo, the total capacity is 175 MW. The total capacity of the existing HPP within the Ministry exceeds 439 MW. By 2015, 4 new HPP are scheduled to be brought online in Tashkent Province: The Lower Chatkal on the Chatkal River with a capacity of 100 MW and a cost of \$105.5 million, the Akbulak HPP on the Akbulak River (60 MW and \$62.8 million), the Kamchik HPP on the Akhangaran River (30 MW and \$34.5 million) and the Irgailiksay HPP on the Ugam River (13.6 MW and \$25 million). The construction of the Pskem HPP and Myllalak HPP on the Pskem River, with capacities of 404 and 240 MW, respectively, is also envisaged. In Surxondaryo Province, plans are in place for the construction of the Nilo-II HPP on the Sangardakdarya River with a capacity of 30 MW (\$33.3 million) and the Zarchob HPP (90 MW) on the Tupalangdarya River. Overall, for the 2011-2015 period, the electricity sector of Uzbekistan is expecting 44 investment projects to be implemented at a total cost of \$5.27 billion (RU, 2011b). At the same time, Uzbekistan is also building new, large reservoirs (Kengulisai, Zhiidaliy, Rezaksai). In 2008, construction on the Chartak reservoir was completed in Namangan Province. Construction of the Rezaksai reservoir, which had a total estimated cost of \$46 million, was completed using a loan from China.

Central Asian rivers are characterised by two periods of increased water levels – the spring floods caused by rainfall and snowmelt and the summer floods caused by melting glaciers. The spring runoff is stored in reservoirs for later irrigation use. The increased summer flow coincides with the period of greatest water need for crops and this inflow covers the deficit for water consumption. During this growing season, the increased discharge of water from the reservoir for irrigation leads to a growth in the HPP electricity produced, exceeding the needs of the producing countries (Kyrgyzstan and Tajikistan).

These hydrological particularities of regional water sources and the regulation of their use are the basis for the role of the Unified Energy System of Central Asia (UES CA). Presently these factors are not accounted for – the excess of summer electricity within the region declined sharply because of interstate limitations, leading to significant economic losses and growing tension in regional multilateral relations. Kyrgyzstan and Tajikistan believe that the solution to this problem could possibly be exporting surplus electricity to foreign markets not just in the summer months but also during other times of the year. Kyrgyzstan and Tajikistan plan to introduce new generation and transmission capacities and attract a significant amount of foreign investment in order to do so. The national power grid in

these countries is in urgent need of major repairs, modernisation of existing plants, and technical renovation of the existing infrastructure. The expected diversion of project funds over the long-term does not encourage economic growth in the country. Moreover, the unresolved issues concerning the synching of energy and irrigation with the operating regimes of reservoirs does not encourage energy and water security in the region, greater trust in interstate cooperation, or integration processes in general.

A strategy of independent energy and water policy in the Central Asian countries leads to a reduction in the interstate flows of electricity within the region and a decline in coordinated power grids. Thus UES CA has practically lost its purpose in ensuring the safe operation of power systems. Expert evaluations show that this scenario could lead to large-scale negative consequences for all the countries in the region. When HPP operating modes are not balanced with irrigational and environmental needs, the compensatory ability of reservoirs long-term regulation during droughts and low water is lost, thus creating a threat to food and environmental regional security. When countries' power systems start working in isolation, the coordination of their operations stops and, consequently, so does the functioning of the UES CA. Socio-environmental consequences and the cumulative economic damage on countries in this scenario can result in energy suppliers significantly increasing their profits by selling electricity outside the region, worsening the political tensions between the Central Asian republics and weakening the regional security.

As mentioned, the large basin area (Aral Sea) is far removed from the world's oceans and is a closed-off, endorheic and arid territory, disconnected from other basins. The geographical location and the orographical nature of the Central Asian territory cause special river regimes that have historically influenced the economic structure of farming. When planning the development of hydropower, it is, of course, necessary to account for the particularities of the basin and the formation of its water resources, transboundary water management and the increasing water scarcity. The supply of electricity outside of the region should be in synch with the interstate water management regimes. Without this pre-condition, the export of electricity to foreign markets, that is, outside of a closed water basin (of a region) with limited water resources, may become a factor that adversely affects bilateral relations, energy, water, food and environmental resource security in CA.

International practice shows that development of the regional energy sector is more sustainable when power systems work in parallel. It provides the ability to optimise power generation and increases the efficiency of thermal generation. The advantages of UES CA power systems working in parallel operation also include the ability to redistribute loads and their optimisation with respect to

the regional time zones. This mode allows for a wider use of renewable energy in place of additional generation. The need for to restore synchronised power systems in the UES CA is dictated by the economic and technical practicality. The economic effect from restoring a parallel operating mode compared to an isolated power system may range between \$1.6-2.1 billion across the entire region in the first three years (WB, 2010).

The economic effect is achieved by increasing the reliability of the energy supply and efficient use of primary fuels and hydropower resources. Optimal use will help reduce natural gas and coal consumption, accumulate water in dry seasons, and prevent floods through sustainable interstate water use. This in turn dramatically reduces the need for long-term investment in the construction of long stretches of power lines.

Large HPP located on multi-purpose reservoirs should be linked to the operating modes of the power system. Despite the fact that every country mainly provides for its own energy needs from their own resources, this mode requires the exchange of fuel and energy resources and, therefore, for concerted efforts to implement it. Energy power in Central Asia is connected to water and ultimately to agriculture and this needs to be reflected in the operation of the power grid.

With regard to the need for effective water resource management and cooperation in this area in order to address regional water and energy problems, the well known Soviet scientist and hydrologist M.I. Lvovich pointed out that, in his opinion, “the lack of water in Central Asia takes place in dry years, like in 1974 for example, when the flow of the Syr Darya and the Amu Darya was 30% less than the average annual flow (in 1961 and 1962, the water output in the Syr Darya and number of other rivers in CA decreased more than 40% from their normal levels)” (Frolov, 1965: 219). However, in wetter years the water is always in excess. In 1969, the flow of the Syr Darya and the Amu Darya exceeded the annual average by more than 50 km<sup>3</sup> and some of the Syr Darya’s flow was discharged into the Arnasai depression.

Similar water level contrasts in other years have adversely affected the security of the national economy, which is why the value of long-term regulation of the river flow is well understood, especially in Central Asia where the main industry is agriculture and irrigated agriculture and in low water periods great damage is suffered. The main way to increase the efficiency of using water resources in Central Asia is the long-term regulation of the river flow with the aid of reservoir systems, built in the mountains where water resources form. The existing reservoirs, along with those under construction, have achieved a large volume, but it is important to bear in mind that these bodies of water, running on a HPP schedule, far from meet all the needs of irrigated agriculture and water supply – and

their operation is even often contrary to these goals. The question of priority over the use of water resources is of great importance to the region.

In addition to the provision of a guaranteed water supply, another acute problem is the quality of water, especially in the lower reaches of the rivers where large portions of the river flow are saline after the return of water from irrigation. The industry of water management in irrigation reservoirs could be provided concurrently with energy production and still be quite effective for approximately half of its functions. However, the damage that would be inflicted on hydro energy could be made up by TPP or by HPP facilities in different regions, first and foremost where there is not a large need for water for irrigation. Hydrological forecasts also play a major role as they are the basis for planning the use of water resources. Their importance is growing due to the necessity of planning for long-term reservoir regulation. This is, of course, no easy task especially when one considers the lack of hydrometeorological information in the higher elevated parts of Central Asia. Reliable, long-term forecasts are that the cubic kilometres of additional water for land irrigation are the same as they allow for minimal reservoir capacity to receive maximum water for irrigation. These are the key findings that give evidence to the possibility of increasing the efficiency of use of the local water resources of Central Asia and as the basis for specialised irrigation reservoirs (Lvovich, Tsigelnaya, 1979: 124).

Water policy in CA countries can only be based on the available water resources and their efficient regulation, which increases the role of the reservoir, especially in long-term regulation. The operating regime of hydro facilities should provide not only for seasonal water demand but also create a guaranteed reserve for possible droughts or reduced river water levels.

The unsettled question of interstate power supply within a single Central Asian power system together with joint use of water in transboundary river basins leads to huge economic losses, creating obstacles in the regional irrigational processes. An increased release of water from an upstream reservoir during a period when energy production sharply increases at an HPP dam poses a greater threat to the security of downstream hydraulic structures, human settlements, and economically-important objects. During the summer, the opposite situation is true due to a lack of water for crop irrigation.

Therefore, the countries in the transboundary river basin should strive towards a balanced operating regime for the entire regional energy system as a whole, including the reservoirs and HPP and ensure compliance with the rules of winter operations, the safe passage of flood waters, and water accumulation during the growing season. This is why it is necessary to elaborate a joint plan for the development of the energy and water sectors at a regional level, which should take into account both national measures

(increasing the reliability of energy and water supplies) and the regional interests (strengthening the network and automatic security systems, the installation of additional transformers, etc.).

To this end, it is appropriate to quote the famous Russian lawyer P.N. Kazanskiy in his magnum opus "River Treaties. Essays on the History and Theory of International River Law", published in 1895. He writes: "Modern humanity is not scared by great or small rivers or by the hostile forces that it has learned to tame and make useful to mankind. But in many cases our force is too weak to reach this goal and the state takes on water management, creating special bodies that act on behalf of the public and, relying on social power, are better able to direct water to the service of the people. This usually happens not because problems with water management were so vast that a separate government was unable to shoulder the entire burden, but rather because various enterprises, being in the interest of various peoples, when carried out correctly, may go beyond a single state's borders or may be able to be put into effect only through the specific activities of an international institute. This breadth of issues in international governance is raised mostly in international waters – waters belonging to several states" (Kazanskiy, 1985). This statement is particularly relevant today. There are opportunities to solve the water-energy problems of Central Asia and to reach these solutions one must move towards regional transboundary river management based on integrated use and the protection of water resources, guided by the norms of international law and best practices in this area.

## Chapter 4. Energy Security and Water Resources Management in Transboundary River Basins in Central Asia

Central Asia has sufficient fuel and energy resources to allow the countries not only provide for their own energy needs, but also to cater for foreign markets as well. There are considerable reserves of energy resources, although these vary significantly in their value and type among the states in the region. Kazakhstan, for example, has large reserves of oil, gas, coal, and uranium, many times larger than the potential hydropower resources in the country. Uzbekistan also belongs in the category of countries with, oil, coal and uranium, but its hydropower resources are assessed as moderate. Turkmenistan has some of the world's largest gas fields, but almost no hydropower resources. Stockpiles and the distribution of primary energy resources determine the structure of the fuel and energy balance of governments (UN, 2004: 94).

CA is considered not just as a region with some of the world's largest oil and gas reserves, but it also has possesses of the most important transportation lines. One of the main Central Asian Central (CAC) gas pipelines that allows Uzbek and Turkmen gas to be delivered to Russia, Ukraine, and the Caucasus is routed through Kazakhstan. Uzbekistan is a transit country for Turkmen gas and Kazakhstan – for Uzbek gas.

Regional gas transport infrastructure was created during the Soviet period and gas transport routes out of CA are largely set up in a centralised system to supply fuel to European countries. Four lines from the main gas pipeline run from Turkmenistan through Uzbekistan (and further through Kazakhstan), and one line runs along the coast of the Caspian Sea through Kazakhstan. There are also additional branches of the CAC, from which two are highlighted: between Turkmenistan and Kazakhstan and between Kazakhstan and the Russian Caucasus. Two lines from the Bukhara – Ural gas pipeline begin in Uzbekistan near the city of Gazli (Bukhara Province), cross Karakalpakstan (Uzbekistan) and then proceed through Kazakhstan to the Southern Urals. In addition, there are two other gas pipelines that cross Kazakhstan (Orenburg – Novopskov and Soyuz), which transport gas from Siberian reservoirs

to Europe. New oil and gas routes from Central Asia are being formed in a competitive global energy market and with the growing influence of world powers on the region (ISSA, 2010: 28-61).

In the structure of primary energy resources, gas, coal and oil occupy a special place in CA. 81% of total production and 83.5% of energy resource consumption happen in Kazakhstan and Uzbekistan. If Kazakhstan is the largest producer of primary energy resources, then according to demographic factors, Uzbekistan is a leader in their consumption. Kyrgyzstan and Tajikistan have great potential for hydropower resources, but they do not have sufficient reserves of hydrocarbons, which determine the development of energy in these countries, based on the use of hydropower resources.

	Installed Capacity (MW)					
	TPP	%	HPP	%	Total	%
Kazakhstan	17,252.4	86.7	2,639.7	13.3	19,892.1	100
Kyrgyzstan	716	18.9	3,070	81.1	3,786	100
Tajikistan	318	5.8	5,121	94.2	5,439	100
Turkmenistan	4,536	99.8	9	0.2	4,545	100
Uzbekistan	10,643	85.5	1,810.7	14.5	12,453.7	100
Subtotal for CA	33,441.4	73.2	12,259.7	26.8	45,701.1	100

**Table 4.1**  
Structure of CA  
Power Plants'  
Installed Capacity

Source: WB, 2010; CASA, 2011; Data from government bodies of energy management of CA countries.

Note: as of 01.01.2012

The total installed power generating capacity of Kazakhstan is 19,892.1: 17,252.4 MW from TPP (86.7%) and 2,639.7 MW from HPP (13.3%), including small HPP and other renewable energy resources. 70% of the total volume of electricity is generated by local coal. There are gas turbine power plants operating in the west and south of the country.

Kazakhstan is facing a deficit of electricity, which is covered by Russia's balancing market. The reduction and subsequent elimination of the deficit is planned and will be carried out by constructing new power plants and modernising existing ones. Electricity production in 2010 reached 82.26 billion kWh.

The electric power system in Kyrgyzstan works in parallel with the Central Asian power grid and is supported mainly by hydropower facilities (3070 MW, 81.1%), which provide additional energy in summer and cover the periods of peak load by the UES CA. Thermal power stations (716 MW, 18.9%) are designated for the increased load during winter. Hydropower plants are located mostly in the Naryn river cascade in the southern part of the country. Electricity production in 2010 was 12.06 billion kWh. Kyrgyzstan has the ability to export up to 2.5 billion kWh of electricity during the periods of high irrigation releases from the Naryn HPP cascade.

The total installed capacity of power stations in Tajikistan is 5,439 MW: 5,121 MW are from HPP (94.2%) and 318 MW from TPP (5.6%). Hydropower plants are mainly located on the Vakhsh cascade in the southern part of the country, with the generating capacity of the HPP in the northern region being only 126 MW. The annual production volume cannot meet the demand for electricity in the winter. From the beginning of October to the end of April, there is a deficit of electricity of about 4 billion kWh. In the winter, Tajikistan is forced to limit the demand for electricity. In the summer, the country has a surplus of electricity, the volume of which depends on the amount of water released from the reservoir and the hydrological conditions that year. In 2010, electricity produced from Tajikistan's HPP exceeded 16.4 billion kWh with its highest excess in recent years at 4.5 billion kWh. As Tajikistan has been shut off from the main UES CA network, it cannot export electricity outside the country and for this reason is facing great economic losses.

Turkmenistan's generating capacities is most in its TPP, which use natural gas as the primary fossil fuel. The total installed capacity of Turkmenistan's power system is 4,525 MW: 4,536 MW is from TPP (99.8%) and 9 MW comes from HPP (0.2%) Turkmenistan has a surplus generating capacity for electricity. Electricity production has reached 10.5 billion kWh and greatly exceeds the demand for it, which allows electricity to be supplied to other countries.

Prior to Turkmenistan leaving the UES CA in 2003, excess electricity was 50% and its main importers were Kazakhstan and Tajikistan. As there was no transit agreement with Uzbekistan, Turkmenistan had to leave the UES CA. Currently, electricity exports of 2.6 billion kWh go from Turkmenistan to Afghanistan, Iran, and Turkey. According to Turkmenistan's Strategy for Economic Development to 2020, electricity production will reach 26.4 billion kWh a year with 6 billion kWh exported annually.

Uzbekistan's power system, which is geographically situated in the centre of the unified energy system and has about 50% of the UES CA's total capacity, plays an important role in ensuring a reliable power supply to consumers in the region by facilitating the transit flow of electricity exports to other countries. Uzbekistan's power system has an installed capacity of more than 12,453.7: 10,643 MW from TPP (85.5%) and 1,810.7 MW from HPP (14.5%). Electricity production in Uzbekistan in 2010 was 51.7 billion kWh a year. Almost the entire amount of electricity in Uzbekistan is produced by thermal power stations that use natural gas as the primary fuel. As operating thermal power stations are more effective in their base-load regime, regulating capacity in terms of the lack of hydropower potential is a rather serious challenge for the country's power grid. It is worth mentioning the seasonal nature of the import and export of electricity: Uzbekistan imports

electricity from Kyrgyzstan and Tajikistan in the summer and delivers it in the winter to various regions of northern Tajikistan based on bilateral agreements between the countries. Uzbekistan also exports electricity to Afghanistan. Of all the hydropower plants in Uzbekistan, only the Charvak HS (620 MW) and the Khodzhikent HPP (150 MW) can provide regulation, but the required capacity is more than 2,500 MW. The economically and technologically appropriate solution to the problem of regulating frequency and capacity is the use of advanced interstate power lines with neighbouring countries that have significant hydropower potential, such as Kyrgyzstan and Tajikistan.

The demand for electricity in the CA countries is predicted to grow annually until 2030 at a rate of 1.6-2.6%. One thing the CA countries have in common is a high wear of power station equipment of all types and power lines, which together contribute to a large loss of primary energy resources and produced electricity. Therefore one of the priorities for investment policy in the CA electricity sector should be to implement measures to reduce the technical loss of electricity and modernise the existing generating stations. By reducing the technical losses of electricity and modernising and upgrading generating facilities, the bulk of the forecasted demand in CA could be covered. Bringing new generating capacity online necessary for planned socio-economic development could also be considered as an investment priority.

Central Asia's hydropower potential was valued as early as the beginning of the 19<sup>th</sup> century. Deutsche Wasserwirtschaftskrafte printed an article titled "The Earth's Water Power" which gave a brief inventory of the world's water resources including an overview of hydropower reserves in the then USSR. The numbers bear witness to the fact that Central Asia has the richest reserves of water energy (after the Caucasus) in the then USSR. From these numbers, it follows that Central Asia occupied first place in the USSR in terms of quantity and total capacity of the largest water energy resources (Davydov, 1925: 91-93).

A current assessment of Central Asia's hydropower potential is presented in Table 4.2.

**Table 4.2**  
Central Asian  
Hydropower  
Resources

Source: UNESCO,  
2010; Molodtsov,  
2010

Note: 1. Gross hydropower potential: energy equivalent of hydropower energy reserves concentrated in sources of potential hydropower at full usage; 2. Technical hydropower potential: part of the gross hydropower potential that can be used by modern technology to meet requirements of a socio-environmental nature; 3. Economic potential of hydropower: part of the technical hydropower potential whose use under current conditions is economically effective to meet requirements of a socio-environmental nature; 4. Utilised potential of hydropower: hydropower that is used.

Countries	Hydropower Resources (potential, billion kWh annually)							
	Gross		Technical		Economic		Utilised	
	Total	share in CA (%)	Total	share in CA (%)	Total	share in CA (%)	Total	share in CA (%)
Kazakhstan	170	15.8	30	6.3	23.5	5.71	9	17.7
Kyrgyzstan	249	23.1	99	20.9	55	13.3	14	27.6
Tajikistan	527	48.9	317	67.1	317	76.86	19.5	38.4
Turkmenistan	24	2.2	5.8	1.2	2	0.48	0.1	0.18
Uzbekistan	107	10.0	21.1	4.5	15	3.65	8.2	16.12
Total	1077	100	472.9	100	412.5	100	50.8	100

The total gross hydropower potential of Kazakhstan is theoretically 170 billion kWh a year, of which 27-30 billion kWh is cost effective and viable for use. Accounting for the changing river water levels, the gross energy potential in Kyrgyzstan from 268 rivers (linear accounting), 97 of the largest canals, and 18 reservoirs studied is 249 billion kWh of electricity produced a year at average water levels. 99 billion kWh a year are economically justified for utilisation (<http://www.caresd.net>).

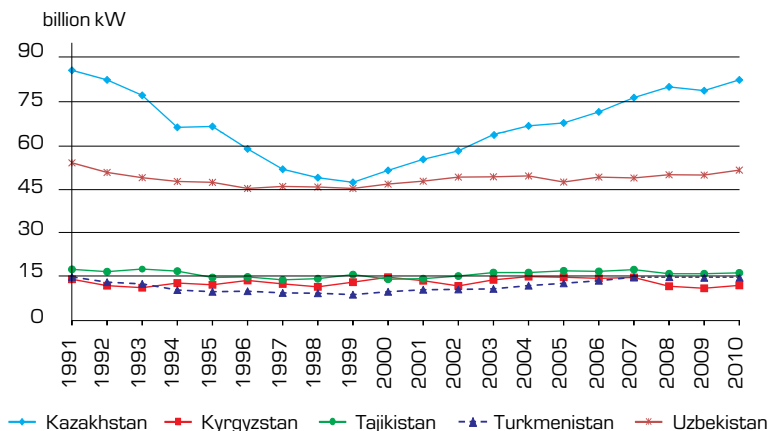
Tajikistan has significant hydropower resources. An assessment of their reserves, based on direct observations of 530 (from a total of 947) rivers in the country and on primary data from the Hydrometeorological Service, shows that the gross hydropower potential is 527 billion kWh, while technical potential – also accepted as economic – is more than 317 billion kWh a year (RT, 2007: 29-31).

Turkmenistan has no hydropower resources that are sufficient for use with the goal of regulating the country's power capacity. Nonetheless, Turkmenistan has had experience in making use of rivers hydropower. The oldest hydropower plant in the CIS – the Hindu Kush HPP – is located here. At the end of the 19 – beginning of the 20<sup>th</sup> centuries, three dams were built on the Murghab River (Turkmenistan) for irrigation: the Yoloten, Syltanbent and the Hindu Kush, the last two of which had hydropower plants constructed on them. The Murghab River is a transboundary river that originates in Afghanistan. The Hindu Kush HPP was the largest power station in pre-revolutionary Russia. There are three hydro turbines installed in the power plant with a total capacity of 1.35 MW. Power equipment was supplied by the Austro-Hungarian company Hans. Celebrating its 100<sup>th</sup> anniversary, the Hindu Kush HSP is still in operation, annually producing on average 0.8-0.9 million kWh of electricity.

Potential hydropower resources in Uzbekistan have been adequately studied and compared to other forms of renewable energy resources. The gross potential of 656 rivers and their tributaries is 107 billion kWh a year. Uzbekistan's hydropower resources were estimated taking into account the potential of both large and small rivers; existing, under construction and project reservoirs, master irrigation canals and main trunk canals with a discharge between 50-158 m<sup>3</sup>/s and which have a possible drop of 2 to 120 m. The technical potential of hydropower resources is estimated at 21.1 billion kWh a year.

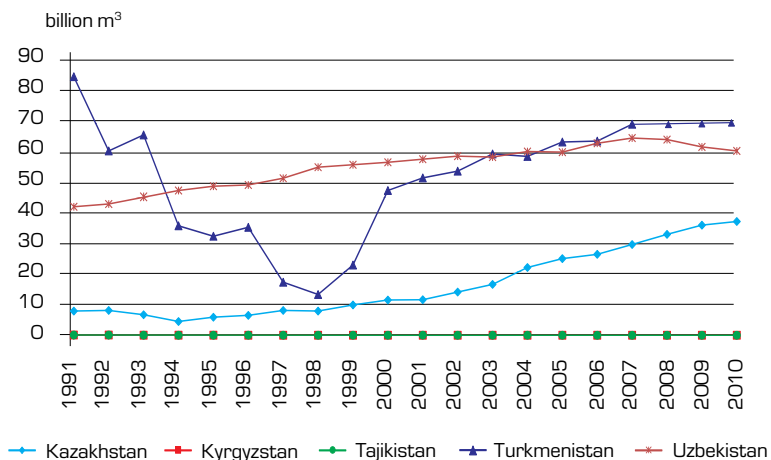
The geographical distribution of primary fuel and energy resources objectively stipulates the structure of the Central Asian states' generating capacity as well as the need for and feasibility of regional energy integration on the basis of exchange (export-import) of electricity and various other forms of energy.

During the Soviet time, accounting for the territorial particularities, Central Asia saw the creation of a fuel and energy complex that had a high level of



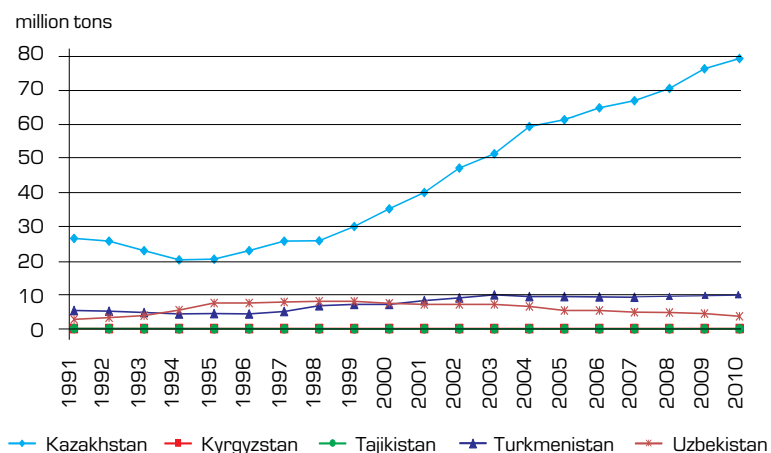
**Figure 4.1**  
Dynamics of Electricity Production in Central Asian Countries

Source: CIS ISC



**Figure 4.2**  
Natural Gas Production

Source: CIS ISC

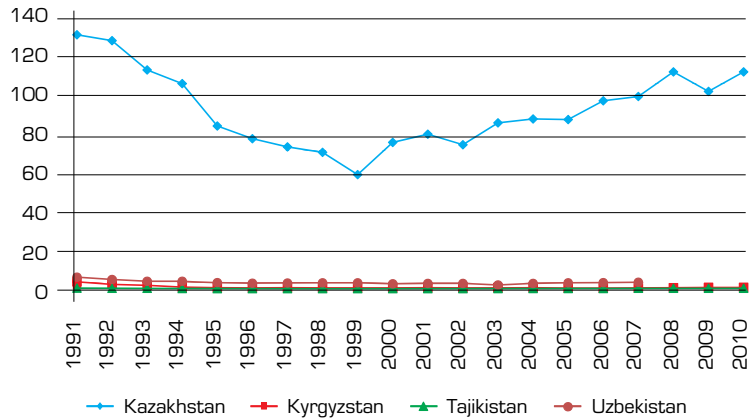


**Figure 4.3**  
Oil Drilling, including Gas Condensate

Source: CIS ISC

**Figure 4.4**  
Coal Mining  
(million tons)

Source: CIS ISC



regional integration. The unified energy system of Central Asia provided a stable mode of operation, reliable interstate supply of hydro resources and a water use regime that was regulated by the hydropower plants in the region.

The UES CA, including the power systems of Uzbekistan, the southern regions of Kazakhstan, Kyrgyzstan, Tajikistan, and Turkmenistan was designed based on unified criteria for the system to operate at the lowest cost. The regional electricity infrastructure of CA, which in turn was part of the UES of the USSR, was built to be an integrated system, optimally using the available fuel, energy and hydropower resources in the region. The UES CA is a set of electricity facilities, exploitable resources, and their management, linked by a single process of electricity production, transmission and distribution. One of its more important advantages was the ability of the participating states' electricity systems to operate in parallel to one another – i.e. electricity systems working together on a common frequency.

The parallel operation of electricity systems is a prerequisite for reliable operation and creates the basis for mutually beneficial cooperation in the electricity industry. The main principles of parallel operating power systems are:

- satisfy the demand for electricity and capacity in each power system at all times through either their own power stations or energy delivered from other states on a contractual basis;
- maintain the standard frequency within the agreed range in every power system through either its own sources of energy and/or through cross-flows from power systems in other states; and
- maintain the required reserves in every power system and supply the missing amount of reserve on a contractual basis from the power systems of other countries.

After the collapse of the USSR, in order to maintain parallel operations, the CA countries signed an agreement in 1998 on the parallel operation of the energy system. All technical issues for the operation of the existing 500 kW network and the 220 kW power lines were placed under the control of the Coordinating Council of UES CA. It consists of the national operators of the generation, transmission and distribution systems:

Kazakhstan: JSC KEGOC – network operator;

Uzbekistan: State JSC UzbekEnergo – vertically integrated state energy company for production, transmission, and distribution;

Tajikistan: JSC Barki Tochik – vertically integrated state energy company for production, transmission, and distribution;

Kyrgyzstan: JSC NESK – network operator; JSC Power Plants – generation;

Turkmenistan: State Corporation Kuvvat - vertically integrated state energy company for production, transmission, and distribution;

The Coordinating Council of the UES CA established Energy, a Coordination Dispatch Centre (CDC), located in Tashkent and functioning as the first hierarchical level of the power system's dispatch of Central Asia. The role of second level dispatch centres in the CA countries is filled by separate organisations that are involved in the dispatch of the national power system. CDC Energy is funded on the principle of shared costs between the parties involved.

As a regional system operator, CDC Energy shall ensure compliance with the principles of parallel operation and operational coordination based on the information received daily from the national dispatch centres. These centres make use of instructions and recommendations from CDC Energy. However, not all countries in the region support joint operation, which greatly reduces the opportunities for regional energy security and interstate water use in the transboundary river basins. Uzbekistan has limited its participation in parallel operations and the power systems of Tajikistan and Turkmenistan function in isolation from the UES CA. Moreover, Turkmenistan's power system has changed in configuration and in order to restore the technical parameters and lines connecting it to the other countries in the region, significant investment is needed. The economic losses from isolated power system operations are considerable. As a result of a fragmented UES CA and its unstable parallel operations, CDC Energy is not fully exercising its functions. Instead, it has been reduced to mostly monitoring capacities (the flow and production from large hydro and thermal power stations, and the demand for electricity in the separate units); the operating of automatic load-frequency control, the distribution of delivered and needed amounts of electricity for balancing; and to providing analytical and advisory services.

The effectiveness of the CA's power system control mechanism and the corresponding HPP operations have fallen sharply with the loss of its regulatory functions as a result of the trend of national power systems leaving this system. The bulk of electricity exports and imports between countries in the region are maintained in the summer when water releases from reservoirs are necessary for irrigation needs in Uzbekistan and Kazakhstan. But this regime is fraught with difficulty because of the abeyance of mutual commitments and the conditions of fulfilling them. The volume of regional electricity trade has decreased from 25 GWh in 1990 to 3.7 GWh in 2008.

**Table 4.3**  
Electricity Trade  
in Central Asian  
Countries, averages  
for 2000-2008

Source: CAREC,  
2009: 4

Export	GWh	Import					Total Exports	Net Exporter (+)/ Net Importer(-)
		Kazakhstan <sup>1</sup>	Kyrgyzstan	Tajikistan	Uzbekistan <sup>2</sup>	Turkmenistan		
Kazakhstan <sup>1</sup>		X	0	2.3	0	0	2.3	-1,718.3
Kyrgyzstan		1,642.2	X	223	515.9	0	2,381.2	2,230.1
Tajikistan		69.6	62.6	X	560.5	0	692.7	-657.8
Uzbekistan <sup>2</sup>		0	88.4	705.2	X	5.2	798.9	-284
Turkmenistan		8.8	0	419.9	6.5	X	435.2	430
Total Imports		1,720.6	151.1	1,350.5	1,082.9	5.2	4,310.4	0

Notes: <sup>1</sup> – Kazakhstan's imports also include electricity for further export to RAO UES.

<sup>2</sup> – Uzbekistan's exports to Tajikistan include conditions in the intergovernmental agreement TALKO

As noted in the "Analysis of energy management and the reciprocal exchange of energy between nation power systems in the Central Asian region" (WB, 2010), Kyrgyzstan, Tajikistan, Uzbekistan and Southern Kazakhstan can fulfil their own electricity needs, but in order to do so, energy systems working in parallel is a necessity. This same study also emphasises that CA countries are trying to increase their energy independence and grow their export capabilities beyond the region, and, not having sufficient funds to upgrade their energy infrastructure, are reducing the amount of regional energy cooperation. Achieving the criteria for a reliable, national power system is only possible through a unified power system. The results of a SWOT analysis and a simulation of the CA power systems within this research shows the significant benefits of the CA power systems working in parallel, one of which is an increase in the reliability of the supply.

The simulation results show that through parallel operation of CA power systems, it is possible to save more than \$1.6 billion in the first three years of a fully-functioning unified system. Given that losses due to an undersupply

<p><b>Strengths</b>                  Optimal use of natural resources.                  Optimal scheduling.                  Efficient use of thermal generation.                  Decrease in necessity of investments.                  Use of advanced regional network.                  Reduction in undersupplies of energy.                  Improved reliability of supply.                  Decrease in the need for secondary reserves.</p>	<p><b>Weaknesses</b>                  Potential risk of violation of agreements by other participants.                  Potential risk of emergency situations in neighbouring countries (which are compensated by the ability of neighbouring countries to offer support).                  Lapse in energy supply, leading to social and economic harm.</p>
<p><b>Opportunities</b>                  Ability to resolve:                  Issues of electricity and water resources (complex solutions).                  Issues with transit and customs duties.                  Issues related to import-export of electricity.                  More incentives and better conditions for the development of projects that are regional in scale.</p>	<p><b>Threats</b>                  Issues of national energy security, primarily, the independence from external energy resources.                  Could lose priority access.</p>

of electricity by users reached no less than \$200 for 1 MW, a stable and operational power system can have a positive economic effect of more than \$0.5 billion. Thus, in the first stage of transition of CA power systems to this mode of operation, expected savings will exceed \$2.1 billion. In general, the benefits of a unified power system outweigh any possible shortcomings. The UES is beneficial to all participants from both a technical and an economic viewpoint.

**Table 4.4**  
 Results of the SWOT Analysis for the United Energy System

Source: WB, 2010

The current economic atmosphere is forcing every country to exercise its own energy policy, often conflicting with the prospects for the development of a regional power framework. In the structure of Kyrgyzstan’s generating capacity, for example, 81.1% is from hydropower and 18.9% from thermal power and in Tajikistan hydropower accounts for 94.2% and thermal for just 5.8%. With a limited transit flow of electricity among the UES CA, this type of generating capacity ratio makes energy supply in winter difficult for these countries. They are therefore considering and implementing plans to bring new HPP generating capacities online. However these solutions do not fully take into account their impact on the short-term energy security and interstate water use for the whole region. Energy development is seen more from the position of being able to export the excess capacities outside the CA borders without sufficient regard for their own and regional needs in the future. Forecasts show that Central Asia is expecting an increased need for electricity between 2020-2050 due to the dynamics of economic development and population growth. This period coincides with the forecast of climate change and a stable reduction in water levels in the Syr Darya and Amu Darya basins. With insufficient accumulation in the reservoirs, drawdown for electricity needs could lead not only to a reduction in the electricity produced but to a deficit of water during the growing season, the loss of the long-term

regulation of reservoir, capacity and worsening conditions in interstate water management.

As international practice shows, the attitude of the individual countries in CA in developing hydropower alone does not provide a proper measure of energy and water security for the region. It is therefore necessary for all the Central Asian republics to diversify energy their sources and ensure reliable electric power. Coal could play an important role in raising the sustainability of the energy supply and combating the rise of regional power imbalances. Creating transportation corridors for the delivery of coal to thermal stations, adopting preferential tariff regimes for this type of energy, and the use of clean coal technologies will enhance its competitiveness in comparison to other types of fuel and ensure a reliable energy supply.

The production of energy from renewable sources such as the wind or sun or from the use of small hydropower plants is still quite expensive, but these sometimes present the cheapest means of providing electricity to rural populations. It is necessary to quickly develop new and effective technologies for the use of renewable sources of energy. However, the most reliable and guaranteed source for cities and major settlements is still coal.

In general, the region is considered to have an overabundance of coal, allowing for a wider scope of coal use in building new TPP. Incidentally, this is a worldwide trend: according to forecasts, by 2025 coal will provide 31% of the world's electricity. By 2025, coal will account for 50% of the total energy production in the US. China's use of coal in electricity generation will increase from 72% in 2001 to 73% by 2025. Coal is a flexible source of energy and although today it is mainly used for electricity production, it can also be processed into synthetic gasoline, diesel, hydrogen or other types of transport fuel. New technologies mean that there is also the potential for coal to reduce oil consumption. Kazakhstan is one of the large coal-mining countries of Central Asia (3.5% of the world's coal reserves). The presence of large reserves and the reliability of the supply could help eliminate in a relatively short time the disparities in the generating capacity structure in Kyrgyzstan and Tajikistan, thereby increasing their energy security.

Energy production using coal is also competitive in terms of price. To overcome the negative environmental effects of using coal will require the development of new technologies and applying them on an industrial scale. Upgrading of existing facilities and the construction of new facilities using modern technologies that increase the efficiency ratio will make a positive difference in the volume of emissions and control in greenhouses gas emissions.

Another promising source of electricity in the region is uranium. 17% of the world's reserves are located in Central Asia with Kazakhstan and Uzbekistan

being among the top ten reserves of uranium and in possession of advanced technologies for its extraction. Kazakhstan has 1.6 million tonnes of proven uranium reserves, which makes it second in the world. With its common geological position, historical traits and territorial remoteness, Kazakhstan can be viewed as having six uranium provinces: Shu-Sarysui, Syr Darya, North Kazakhstan, Caspian, Balkhash, and Ili (kazatomprom.kz).

Uzbekistan is seventh in the world in uranium reserves and fifth in its extraction. Uranium mining and processing also takes place in Kyrgyzstan and Tajikistan and the prospects for a nuclear industry are tied to the development of earlier-proven ore deposits. States in the region that have sufficient reserves of uranium and a nuclear industrial complex can cooperate in the development of nuclear energy.

It should be noted that as a result of the prolonged and intensive mining and processing of uranium ore, the region has accumulated a large amount of radioactive waste stored in tailing ponds. Many of these are located near tributaries of the transboundary rivers. Because of the unsatisfactory state of the tailing ponds, they present a threat to the public and the environment and in the event of an accident, the waste may fall into the rivers and spread over large distances. Tailing ponds are in need of major repairs and preventative measures need to be taken to prevent the release of radioactive substances into surface and ground water. The problem is regional in nature and the CA countries could work together to develop programmes and implement practical actions to dispose of tailings and waste (Ibragimov, 2010: 77-104).

Kazakhstan, Uzbekistan and Turkmenistan have significant natural resources (Tajikistan and Kyrgyzstan are more limited in this regard): oil, gas, gold, and other minerals. All these countries have well-developed infrastructure, human resources, and each has the potential to implement their planned social projects. The global situation in terms of raw minerals, especially energy, is also conducive to economic development in the region.

# Chapter 5. Management of Transboundary Watercourses in Central Asia

## 5.1 International principles on the use and conservation of water resources in transboundary river basins

The concept of an international river basin was formed with the introduction of the term “geographic area”, which covers two or more states and defined boundaries of a watershed, including surface and ground waters that flow into streams of general importance (Rules, 1966). The concept was reflected in international conventions on transboundary waters and forms the basis of a large number of bilateral and multilateral agreements in this field.

Almost half the world’s surface water resources – 19,000 km<sup>3</sup> – are accounted for in the world’s 25 largest rivers. Of them, 20 are international (transboundary) and their flow exceeds 16,000 km<sup>3</sup>, or 87% of the river’s water resources. There are 263 transboundary rivers of lake basins in the world, covering nearly half the land surface and containing about 60% of the world’s fresh water reserves. The territory of 145 countries is partially located within the boundaries of international waters. 40% of the world’s population lives in river and lake basins shared by two or more countries, and counting countries with common basins, it is more than 90% of the world’s population. In addition, the main source of water for approximately 2 billion people is the groundwater concentrated in 300 transboundary aquifer systems (basins)<sup>1</sup>.

In the world there are 19 river basins that belong to five or more countries. The Danube basin, for example, includes 17 countries. The basins of five rivers: the Congo, the Niger, the Nile, the Rhine and the Zambezi belong to between nine and eleven countries. Thirteen river basins (the Amazon, the Ganges–Brahmaputra–Meghna, Lake Chad, Tarim, the Aral Sea, the Jordan, the Kura–Aras, the Mekong, the Tigris–Euphrates) are located across the boundaries of four and eight countries. The Mekong river basin includes China, Cambodia, Laos, Thailand and Vietnam; the Tigris and Euphrates river basin includes Turkey, Syria, Iran, and Iraq. The Syr Darya and Amu Darya include Afghanistan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan. This list of international river waters could go on and on.

---

<sup>1</sup> [www.un.org/russian/ga](http://www.un.org/russian/ga)

International relations in the use of water resources flowing through multiple territories are regulated by universally recognised norms in international law and special arrangements at a regional, basin, or bilateral level where the agreements were made by the states concerned.

The development of a legal mechanism for joint water resource management that takes international experience into account is one of the main solutions for the numerous contradictions at both regional and national levels. Sustainable economic development in transboundary river basins depends on effective interstate cooperation and collaboration and a unified legal framework in the field of water relations.

An analysis of interstate agreements for transboundary water resources indicates that issues of cooperation cover various areas of water use. Out of 145 agreements reviewed by experts, 37% concern the use of water, 39% concern hydropower, 9% on flood control, 6% on industrial water use, 4% both on issues of navigation and pollution, and 1% on fishing (UNDP Human Development Report, 2006). Agreed joint water use practices are not geographically distributed across all international waters: of 263 interstate basins, 157 still do not have legal regulation (Dombrowsky, 2008).

International rivers and their riparian states are not constant in terms of their quantity. With the formation of new states, their numbers usually increase and rivers that once had national status become international and the states themselves become coastal parties.

The definition of “transboundary waters” refers to any surface or ground waters that mark border, cross the border of two or more states, or are located on the borders and the definition of “international watercourse” means a watercourse that is a system of surface and ground waters, that, by virtue of their physical relationship, constitute a unified whole, parts of which are located in different states (UN, 1997).

On rivers that cross the territories of several countries, hundreds of large waterworks facilities have been built and are active. These include large dams and the reservoirs they create, hydropower plants, and facilities for diverting water for irrigation and water supply. Most of these waterworks facilities were built in agreement with the other countries located in the river basin where these facilities are located, or even in partnership with neighbouring countries (mostly the case for the facilities on those parts of the river that form state boundaries).

Particular emphasis should be placed on the fact that no other feature in transboundary infrastructure, for example highways or railways, causes as many disagreements between parties as do waterworks facilities on international watercourses. This is caused by a number of objective reasons. First of all, there is no specialised legislation that would comprehensively

regulate the legal relations in the construction and operation of hydraulic facilities on international rivers. The earliest conventions contained, for example, general rules for using rivers for one purpose or another, but they did not cover the whole variety of water relations at an international level. Thus, the League of Nations, the predecessor to the UN, adopted the “Convention and Statute on the Regime of Navigable Waterways of International Concern”, which was signed by 40 nations and determined the general rules for transboundary river use, primarily in terms of navigating waterways, and marked the inadmissibility of actions that impede international navigation and cooperation<sup>2</sup>.

Another convention of the League of Nations focused on hydropower – the “Convention Relating to the Development of Hydraulic Power Affecting More than One State”, signed by 15 nations in Geneva on December 9, 1923, still has many relevant provisions in it<sup>3</sup>. This is an international agreement that entered into force in 1925, although it was not widespread, and subsequently was not included in the list of League of Nations’ conventions and agreements, the conditions on which the UN was created in 1945. It should be noted that the Conference laid the foundations of international water law, which were developed in different conventions and agreements on the use of international watercourses (transboundary rivers). In Article 1, the rights are recognised of each State to carry out whatever works it wishes within the limits set by international law in order to use hydropower resources. The Convention contained provisions on entering into negotiations with concerned states in the event of serious harm to either party where principles of compensation for damage due to work conducted were not established. Thus, Article 2 states: with the goal of rational use of hydropower, negotiating parties shall assist one another in the joint development of hydropower resources taking mutual interests into account. In the event of changes to the adopted programme of water resource development, negotiating parties should examine the new conditions. Article 3 states that: when constructing hydropower facilities, states shall enter into negotiations with the goal of concluding agreements that will resolve the problems. Article 4 specifies the need for negotiations in the event of possible negative effects impacting water bodies in the neighbouring countries. Article 6 of the document states that the agreements may be reflected in the features of the construction, maintenance, and operation of the facilities; in questions of their financing; the implementation of technical security control facilities; security of installations; the regulation of river flow; and methods of resolving disputes concerning the interpretation or application of the provisions of the agreement. In

---

<sup>2</sup> *Convention and Statute on the Regime of Navigable Waterways of International Concern*. [www.un.treaty.org](http://www.un.treaty.org)

<sup>3</sup> *Convention relating to the Development of Hydraulic Power affecting more than one State and Protocol of Signature*. [www.un.treaty.org](http://www.un.treaty.org)

accordance with Articles 3 and 4 of the Convention, the performing works that cause significant harm to another state do not require the consent of that other state. It may rely only on negotiations with the country performing these works, which at best, may lead to some form of compensation of damages, and at worst, if no agreement is reached, compensation of any kind will not be paid. However, these provisions are quite contrary to the fundamental principles of modern international law, which is most likely the reason that this League of Nations' Convention was left behind. Transferring the provisions of these documents into modern international relations concerning the use of transboundary rivers is hardly appropriate, but the general principles could be considered in the development of standards in international water law.

The UN Convention on the Law of the Non-Navigational Uses of International Watercourses (UN, 1997) is expected to become a universal international legal regulation containing guidelines and standards for the use of water resources shared by several countries; however, the Convention has not been enacted yet. To date, it is the most in-depth document to codify the international water law. It took almost 30 years to prepare the Convention and eventually it appears to be a compromise; some of its articles even required voting, which demonstrates the different views that the participants of the process had on some fundamental issues. The 1997 UN Convention is a framework agreement, which sets general approaches and legal principles. Bilateral or multilateral agreements on specific international watercourses can be framed and negotiated based on these approaches and principles. The provisions of the Convention are general and serve to be guiding principles for the preparation of more detailed agreements on specific watercourses. The principles of equitable and reasonable utilisation, prevention of significant harm and obligation to cooperate reflect the generally recognised customary rules of law. The provisions of the Convention can be interpreted in different ways, and the parties participating in a negotiation process may propose their own understanding of the provisions, which, for the most part, are broadly laid down. At the same time, it should be considered that if the Convention became effective, all of its provisions would be legally binding only for the countries that have joined the Convention. For the Convention to become effective it needs to be ratified by 35 states. So far, 20 states have done this and another 15 states are needed to support the process. In Central Asia, only Uzbekistan has joined the Convention (in 2007).

**The UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes (UNECE, 1992)** was signed on March 17, 1992, and became effective on October 6, 1996. This is the first international document laying down a legal framework to promote cooperation for the protection and reasonable utilisation of transboundary waters within a region as a whole. The Convention is a global one and may

be joined by the UNECE member states and from November 2003 by any UN member state. The UNECE region covers European, North American and Central Asian countries and Israel. To date, 38 states participate in the Convention. The party to the Convention is the European Union. From the Central Asian countries it is Kazakhstan and Uzbekistan that have joined the Convention.

This Convention, which is often referred to as “the Helsinki Water Convention”, is aimed at the creation of a legal framework to promote cooperation in the protection and utilisation of transboundary waters in the ECE region. After joining the Convention, the parties shall take all relevant measures:

- a) to prevent, control and reduce pollution of waters causing or likely to cause transboundary impact;
- b) to ensure that transboundary waters are used with the aim of ecologically sound and rational water management, conservation of water resources and environmental protection;
- c) to ensure that transboundary waters are used in a reasonable and equitable way, taking into particular account their transboundary character, in the case of activities which cause or are likely to cause transboundary impact;
- d) to ensure the conservation and, where necessary, restoration of ecosystems.

Measures for the prevention, control and reduction of water pollution shall be taken, where possible, at source.

In taking the measures the Parties shall be guided by the following principles:

- the precautionary principle, by virtue of which action to avoid the potential transboundary impact of the release of hazardous substances shall not be postponed on the grounds that scientific research has not fully proved a causal link between those substances and the potential transboundary impact;
- the polluter-pays principle, by virtue of which costs of pollution prevention, control and reduction measures shall be borne by the polluter;
- water resources shall be managed such that the needs of the present generation are met without compromising the ability of future generations to meet their own needs.

As in the case with other framework agreements, the legal regime set by the UN water conventions is continuously developing, particularly through the adoption of complementary and legally binding international regulations,

protocols, as well as other advisory documents such as the various guidelines addressing particular issues contained within the convention.

The Convention focuses on the protection of transboundary surface and ground waters. The parties commit to take both individual and joint measures for the prevention, limitation and reduction of water pollution from point and diffuse sources. The convention sets out detailed obligations for the parties for the reduction of transboundary water pollution, reduced emission of pollutants through the application of low- and non-waste technology as well as contingency measures. The support from the UNECE Helsinki Water Convention Secretariat enables the Central Asian countries, even those which have not joined the Convention, to participate in the activities held under the aegis of the Convention and to be exposed to the experience of cooperation in other transboundary river basins. If all Central Asian countries were to sign the agreement, it would help to establish a common framework for the development of cooperation in the protection and rehabilitation of the regional water ecosystems, including the Aral Sea.

The provisions and recommendations of international conventions are key to the development of a legal framework of intergovernmental relations pertaining to the shared use and protection of water resources. The conventions, which place obligations on the parties that are signatories to them, can be supplemented with protocols, guidelines and statements to the extent that the parties deem necessary to achieve the objectives set. These implementation arrangements enable the parties to the conventions, and other countries that have yet to agree to them, to apply the recommendations made in convention protocols or guidelines relevant to the various aspects of water uses and transboundary water protection. For instance, guidelines have been prepared for many UNECE conventions and these help the convention member countries to develop common policies for the implementation of these conventions<sup>4</sup>. The guidelines also contain recommendations for the establishment of participatory bodies in river basins, and interested countries can choose to put these into practice.

#### **Rio de Janeiro Declaration. UN Convention on Environment and Development (Rio de Janeiro, 1992).**

The Declaration sets out the essential principles of international cooperation and some of them may be the basis for the activities of a joint commission.

*Principle 2.* In accordance with the Charter of the United Nations and the principles of international law, the State has the sovereign right to exploit their own resources pursuant to their own environmental and developmental

---

<sup>4</sup> [www.unece.org/env/water](http://www.unece.org/env/water)

policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.

*Principle 11.* States shall enact effective environmental legislation. Environmental standards, management objectives and priorities should reflect the environmental and developmental context to which they apply. The standards applied by some countries may be inappropriate and of unwarranted economic and social cost to other countries, in particular developing countries.

*Principle 18.* States shall immediately notify other States of any natural disasters or other emergencies that are likely to produce sudden harmful effects on the environment of those States. Every effort shall be made by the international community to help the States so afflicted.

*Principle 19.* States shall provide prior and timely notification and relevant information to potentially affected States about activities that may have a significant adverse transboundary environmental effect and shall consult with those States at an early stage and in good faith.

*Principle 25.* Peace, development and environmental protection are interdependent and indivisible.

**Agenda 21 adopted at the UN Conference on Environment and Development in Rio de Janeiro (1992).**

Agenda 21 provides guidance on the elaboration of national and regional water management action plans. Programme areas related to water management strategies at the national and regional levels are:

- a) integrated water resources development and management;
- b) water resources assessment;
- c) protection of water resources, water quality and aquatic ecosystems;
- d) drinking-water supply and sanitation;
- e) water and sustainable urban development;
- f) water for sustainable food production and sustainable rural development;  
and
- g) impact of climate change on water resources.

**UN Convention to Combat Desertification in Those Countries Experiencing Serious Drought, Particularly in Africa (1994).**

Article 3, Principles, says that in order to achieve the objectives of the Convention and to implement its provisions the Parties should:

- a) ensure that decisions on the design and implementation of programmes to combat desertification and/or mitigate the effects of drought are taken with the participation of the population and local communities;
- b) improve cooperation and coordination at subregional, regional and international levels, and better focus financial, human, organisational and technical resources where they are needed.

**The Convention on Environmental Impact Assessment in Transboundary Context (UNECE, 1991)** addresses the issues surrounding planned activities that may have significant adverse transboundary impact.

The Party of origin shall ensure that affected Parties are notified of a proposed activity.

The affected Party shall respond to the Party of origin within the time specified in the notification, acknowledging receipt of the notification, and shall indicate whether it intends to participate in the environmental impact assessment procedure (Article 3).

The environmental impact assessment documentation that is to be submitted to the competent authority of the Party of origin must contain the required information (Article 4).

The Party of origin shall, without undue delay, enter into consultations with the affected Party concerning, inter alia, the potential transboundary impact of the proposed activity and measures to reduce or eliminate its impact (Article 5).

**The Code of Conduct on Accidental Pollution of Transboundary Inland Waters (UNECE, 1991)** specifies:

#### International cooperation

Riparian countries should, in the framework of bilateral and international agreements or arrangements, define their mutual relations regarding the control of hazardous activities and the prevention of accidental pollution of transboundary inland waters.

#### Functions of international institutions for transboundary inland waters

Joint commissions should be entrusted with the functions of an advisory body, data monitoring and assessment. These commissions will develop common principles for the use of economic instruments at a national level in order to promote the application of safety measures in hazardous activities.

#### Early warning and alarm systems

Countries should set up and operate efficient warning and alarm systems with the aim of obtaining and transmitting the reliable information needed

to counteract accidental pollution of transboundary inland waters. Where appropriate, the countries concerned should perform these tests, reviews and training jointly.

#### Matters to be regulated

National legislative and administrative measures for the prevention, control and reduction of accidental pollution of transboundary inland waters should provide safety regulations.

*The Protocol on Water and Health to the Convention on the Protection and Use of Transboundary Watercourses and International Lakes* (London, 1992) recommends promoting international cooperation in:

- a) the development of commonly agreed targets;
- b) the development of indicators on the prevention, control and reduction of water-related disease;
- c) the establishment of joint or coordinated surveillance and early-warning systems and contingency plans;
- d) mutual assistance in responding to outbreaks of water-related disease and significant threats of outbreaks and incidents, especially from water-pollution incidents or extreme weather events;
- e) the development of integrated information systems and databases, exchange of information and sharing of technical and legal knowledge and experience;
- f) the prompt and clear notification by the competent authorities of one Party to the corresponding authorities of other Parties on the above matters; and
- g) an effective means of disseminating information about water-related disease to the public [Article 12].

#### Cooperation in relation to transboundary waters

Where any Parties border the same transboundary waters, to complement their other obligations under articles 11 and 12, they shall cooperate and, as appropriate, assist each other to prevent, control and reduce the transboundary effects of water-related disease [Article 13].

**The Dublin Statement on Water Resources and Sustainable Development (Dublin, 1992)** sets out the basic principles of integrated water management and international cooperation in transboundary river basins. A river basin, including its surface and groundwater, is proposed as the most appropriate geographic entity for the planning and integrated management of water resources. The effective integrated planning for and development of a

transboundary river or lake basins has similar institutional requirements to a basin entirely within one country.

**The Guidelines on the Ecosystem Approach in Water Management (UNECE, 1993)** contain provisions for the preparation and implementation of integrated water management plans.

**The Guidelines on Water Quality Targets (UNECE, 1993)** address issues of water quality regulation that fall within the ambit of joint river basin bodies.

**The Guidelines on the Prevention and Control of Water Pollution from Fertilisers and Pesticides in Agriculture (UNECE, 1993)** set out legal, regulatory and other measures of agricultural policies to protect water resources. These strategies to prevent, control and reduce adverse effects on water resources and the environment should be integrated into the Party's agricultural and environmental policies.

**The Guidelines on Water-Quality Monitoring and Assessment of Transboundary Rivers (UNECE, 1996)** address the issues of water quality monitoring in transboundary rivers, including:

- institutional aspects. These include institutional arrangements, cooperation arrangements and the functions of stakeholders and competent specialists. International cooperation in transboundary river basin management is necessary, however, the cooperation should take into account the social and economic differences between the countries;
- national agreements. At a national level, the institutional aspects should be arranged by each country and these arrangements should include cooperation between local governments;
- financing. Riparian countries should provide sufficient funding for the execution of the monitoring and assessment and joint research. This funding should be part of their regular budget. Each country should cover its own research.

**Recommendations on specific measures to prevent, control and reduce groundwater pollution from chemical storage facilities and waste-disposal sites (UNECE, 1996)** propose that to ensure coordinated groundwater policies, efforts should be made, where applicable, to concentrate overall responsibility for groundwater with a single authority. Legislation should lay down separate requirements for precautionary and post-care groundwater protection.

**Guidelines on licensing wastewater discharges from point sources into transboundary waters (UNECE, 1996)** identify several approaches

to choosing an appropriate institutional framework for the management of transboundary waters, including the granting or refusal of permits. For licensing, an agreed notification system together with an agreed procedure for impact assessments of the pollution arising from point sources is the minimum requirement.

**Guidelines on Monitoring and Assessment of Transboundary Groundwater (UNECE, 2000)** are intended to assist in the development of harmonised rules for the set up and operation of systems for transboundary groundwater monitoring and assessment. They provide an approach to the identification of problems and guidance to meet information needs. The exchange of information (and joint assessment/modelling) between riparian parties is meaningful only if the data are comparable. This can be achieved when all components of groundwater monitoring activities on both sides of the border use similar principles.

**Transboundary Flood Risk Management: Experiences from the UNECE Region (UNECE, 2009)** recommends measures to ensure sustainable flood prevention. Efforts to manage floods on a transboundary scale should be based on the principles of Integrate Water Resource Management. The basic aim should be to minimise the loss of human life and the economic and environmental damage caused by floods while maximising the efficient use of floodplains. In most cases this approach represents a shift from the current limited perspective of mere “flood defence” to a flood management strategy that is embedded in an integrated water resources management strategy. Transboundary flood risk management enables the sharing and redistribution of risks and resources. Flood risk management strategies should be embedded into the overall joint integrated water resources management of the basin. All riparian countries should take part in this. Existing joint bodies and transboundary agreements often provide the best framework for the development of and obtaining agreement to joint flood risk management plans. Specific questions may be regulated by a specific protocol. Flood risk management strategies should follow all the steps of the risk management cycle: preparedness, response, recovery and finally the reconditioning of the management system. Cooperation is necessary at every step. Insufficient communications, a lack of data and insufficient exchange of information between riparian countries are still major obstacles to proper flood risk management. Political support is needed to make technical cooperation sustainable, long-term and effective in the field of transboundary water management. In many cases, it is not the technical capacity that is missing – i.e. for flood forecasting, early warning and possible measures – but rather the institutionalisation of transboundary flood risk management through bilateral and multilateral agreements and continued cooperation. EU tools such as the European Flood Alert System and those provided by the European Exchange Circle on Flood Forecasting and European Exchange Circle on

Flood Mapping could be useful in the creation of a basin flood management system.

**The River Basin Commissions and Other Institutions for Transboundary Water Cooperation (UNECE, 2009)** contains proposals for ensuring the effective implementation of bilateral agreements to regulate the use and protection of transboundary waters. Joint bodies for transboundary water cooperation serve both as forums and tools for enriching dialogue and decision-making. Existing joint bodies take a variety of forms, cover many areas and offer a wide range of experiences with regard to institutional mechanisms and organisational structures. This publication makes recommendations to improve the performance of existing joint bodies as well as support for new agreements and new joint bodies that can catalyse international action to support new initiatives by riparian states in the region.

**The Guidance on Water and Adaptation to Climate Change (UNECE, 2009)** aims to spur climate change adaptation that takes into account the transboundary dimension of water management. Based on the concept of integrated water resources management, the Guidance provides advice to decision makers and water management bodies on how to assess the impact of climate change on water quantity and quality, how to perform risk assessments, including health risk assessments, how to gauge vulnerability, and how to design and implement appropriate adaptation strategies. The Guidance places special emphasis on the specific problems and requirements of transboundary basins, with the objectives of preventing, controlling and reducing the transboundary impact of national adaptation measures and thereby preventing and resolving possible conflict. Cooperation in adapting to climate change in transboundary basins implies sharing the costs and benefits of adaptation measures, reducing uncertainty through the exchange of information, broadening the knowledge base, and enlarging the range of measures available for prevention, preparedness and recovery.

Countries' mutual interest in making use of international rivers is one of objective grounds for developing cooperation between and among riparian countries. Joint work in the basins of transboundary rivers is based, either directly or indirectly, on the principles contained in the above conventions. These can be laid down as follows. First of all, a riparian country has the right to use the water of a transboundary river to the extent that it is without prejudice to the sovereignty and, thus, territorial supremacy of another country. Mutual respect for national sovereignty is a generally recognised imperative principle of modern international law. The water use by one riparian country should not damage the water use by another country. All issues that may cause significant changes in the state of a transboundary river should be agreed among all interested riparian countries. The water resources of

transboundary rivers should be distributed on the basis of equity and respect to the sovereign rights of each riparian country. Following this principle all riparian countries have a right to an equitable and reasonable share in the utilisation of river basin waters.

The economic development and the ever-growing demand for water as well as the need to address environmental issues in a river basin highlight the importance of cooperation. The studying and planning of water resources development in a river basin, the construction of facilities for various water uses, including for the hydropower industry, and the safety requirements for these facilities, the protection of water quality, etc. – all dictate the need for joint actions. Equitable and mutually beneficial cooperation are essential prerequisites for water use by all the countries in a transboundary river basin.

If there are objections to a proposed project in a transboundary river basin, consultations and negotiations seeking mutually acceptable solutions appear to be the most reasonable and promising way forward.

It is therefore important for countries sharing an international watercourse to enter into constructive cooperation based on equity and trust in order to achieve mutually acceptable agreements. The duty to cooperate is a general obligation of all countries in the international common law, which is also applicable in the area of international relationships over transboundary waters. One should note, however, that the duty to cooperate neither prescribes any specific obligations nor imposes any specific actions and forms of cooperation, rather it is understood as the duty to cooperate in good faith. For instance, Article 8 of the 1997 UN Convention or Articles 2.6 and 9 of the Helsinki Convention contain a general obligation to cooperate in ensuring the optimum use and proper protection of international watercourses.

The cooperation on international watercourses implies issuing timely notification to other riparian countries of plans to implement a project that may have a significant adverse effect on these countries. This obligation results from Articles 12 and 18 of the UN 1997 Convention.

## **5.2. River Basin Organisations**

In the doctrine of international law the cooperation in transboundary river basins is based on some generally recognised principles.

Conflict-free resolution of potential issues surrounding safe water use in transboundary basins can be only ensured in the context of cooperation. In the interests of long-term economic cooperation it is important to maintain the environmental sustainability of the overall river system which includes not just rivers and lakes (surface waters) but also groundwater, and organise the

joint monitoring of water distribution taking into consideration the variations in the runoff and water demand.

The international agreements on shared water use cover 109 out of the 263 existing river basins, i.e. cooperation is maintained only in 42% of transboundary basins (Dombrowsky, 2008). There are less joint river basin management bodies than the above number of agreements. International river organisations are in place in only 62 out of the 263 river basins, i.e. these organisations have been established only in 24% of transboundary basins. *Table 5.1* demonstrates that joint organisations have been established only in 26 out of the 176 river basins shared by two countries (bipartite basins), or 15%. More international organisations have been established in the international basins that are shared by several countries (multipartite basins): 36 out of 87 of these river basins have joint bodies, i.e. these bodies cover 42% of the multipartite transboundary basins.

	No. of international river basins worldwide	Basins with international river basin organisations (IRBOs)		
		Number	Share of total per basin type	Share of basins with IRBOs
All basins	263	62	24%	100%
Bipartite	176	26	15%	42%
Multipartite	87	36	41%	58%

**Table 5.1**  
International River Basins with River Basin Organisations

Source: Dombrowsky, 2008

The specificity and scarcity of water resources dictates the need for policies to maintain the quantitative and qualitative capacities of the water sources, to address social, water management and environmental issues in an integrated manner on the basis of unity of water resources formation within a river basin. River basin organisations need to be established at both international and national levels. These organisations should objectively reflect the interests of all water users, implement achieved agreements, facilitate conflict-free resolution of disputes and the capacity building of national water management authorities. Basin organisations can be either permanent or temporary, they can have mandates for decision-making or prepare recommendations and proposals for national authorities. River basin organisations (commissions or committees) may consist of two or more parties to an agreement and have various authorities and objectives (Klimenko, 1969). *Table 5.2* demonstrates the total number of international organisations. There are 86 organisations, of which 57 (66%) are bilateral and 29 (34%) are multilateral. In addition, river organisations may cover several river basins; there are 7 of these (8% of the total number of river basin organisations). Boundary water commissions have a considerable share: 20 out of the 86 existing international river organisations are boundary water commissions, or 23% of the total number of organisations.

Type of Organisation	Number	Share of Total Organisations
Total organisations:	86	100%
bilateral	57	66%
multilateral	29	34%
Basinwide organisations (multipartite basins only)	7	8%
Boundary water commissions	20	23%

**Table 5.2**

International River Basin Organisations

Source: Dombrowsky, 2008

In their activities international river commissions may cover various issues of water use and water protection. From this perspective, there might be either general or ad hoc commissions.

General purpose river commissions are established for the joint review of perspectives on the development of a river or a river basin. These commissions are generally temporary and cease their work once the review of specific issues is completed. Sometimes a body can be established both for the review of particular issues and for the future management of river water uses.

General-purpose river commissions are most common, though recently ad hoc river commissions have also flourished. The expanding use of international river waters has meant that many of the general-purpose bodies have become more sophisticated in structure and in some case ad hoc commissions have been established on the basis of a general-purpose body. In addition to permanent commissions, temporary commissions can be established to review the prospective uses of a river.

All parties to commission agreements usually have an equal number of their representatives in these organisations. Members of international river commissions often enjoy diplomatic immunity in order to ensure the proper performance of their functions. The operational procedures are usually set by the organisations themselves; however, relevant agreements often contain provisions on specific activities.

There are cases in the relationship between basin countries when parties do not establish a formal river commission, but rather each country appoints its own commissioners. These commissioners are thus representatives of their governments. As opposed to international river commissions, which have regular meetings as prescribed by a relevant agreement, commissioners meet as and when necessary. The only difference between international commissions and commissioners is that the latter have no fixed frequency of meetings. But if in fact these meetings are regular then the activities of commissioners are little different from the activities of many international commissions.

The following observations can be made in summarising the issues related to the arrangements and activities of international river organisations. The

differing names of the organisations do not change the fact that all are international organisations as they consist of representatives of, at least, two countries. However large a commission may be, it comprises an equal number of representatives from each party. Thus, the principle of parity is a precondition for these bodies. Representatives may have deputies, assistants and advisors. Additional support staff and various experts are involved in the relevant activities. The commission members are usually representatives of only those countries that have voting rights in the decision-making process. If two or more commissioners represent each party, sometimes only one commissioner votes even though the other commissioners are also considered to be commission members. Countries often appoint highly qualified engineers as their representatives, who is then both a government official and a government representative in a river commission. Sometimes the representatives are called Commissioners and they often enjoy diplomatic privileges and immunities but to the limited extent required to perform his/her official functions.

International river commissions have different names or scopes of activities. As there are different uses of river water, commissions can be categorised as hydropower, irrigation, fishing, or pollution control commissions. An international river commission usually keeps its activities within the scope of a relevant agreement. It is rare, but there are cases where a commission covers all issues related to river water use rather than being limited by a relevant agreement. The mandate of permanent river commissions usually includes:

- the review/study of specific river water uses;
- the engineering, construction and management of various facilities on rivers;
- oversight and control of the various river water uses;
- facilitating cooperation between/among parties;
- information sharing;
- addressing disagreements between/among parties on the use and interpretation of a relevant agreement.

Commissions usually have meetings once or twice a year and they can also have ad hoc meetings. Decisions are made unanimously or by majority vote and then recorded in the minutes of the meeting. The decisions themselves or the relevant minutes recording decisions often need to be approved by the governments of the parties. A decision is considered to be approved if after a specific period of time there have been no objections from the government of any party.

In some cases the resolution of disagreements between or among parties regarding the application and interpretation of an agreement is not included into the mandate of an international river commission and is addressed by a special parity commission. Thus, commissions may have some powers of authority or alternatively play a more advisory role.

**The Interstate Commission for Water Coordination in Central Asia (ICWC)** was established in accordance with an agreement among the Republic of Kazakhstan, Kyrgyz Republic, Republic of Uzbekistan, Republic of Tajikistan and Turkmenistan on cooperation in joint management and protection of interstate sources of water resources (1992). ICWC and its bodies are part of the International Fund for Saving the Aral Sea. The commission members are the chief executive officers of the water management organisations in the Central Asian countries. Meetings are held on a quarterly basis and each party can also initiate an ad hoc meeting.

The ICWC organisational structure includes the following bodies.

Amu Darya and Syr Darya Basin Organisation based in Khujand and Tashkent regulates water resources use based on the limits set by ICWC and provides for the operation of waterworks, interstate channels and other facilities on the transboundary rivers.

The ICWC Research and Information Centre is an analytical and information body and functions in close cooperation with networks of research and development organisations of the five states. The Centre is based in Tashkent and has branches in three Central Asian countries.

The Coordination and Metrology Centre was established to obtain a uniform view of metrology services and to facilitate control automation at interstate facilities on the transboundary rivers in the Aral Sea basin.

The ICWC Secretariat is a working body of the ICWC and is based in Khujant, Tajikistan.

The scope of the interstate commission's activities includes the training of top and middle management from the Central Asian countries and to this end a Training Centre was established and this is currently operating in Tashkent.

**The Commission of the Republic of Kazakhstan and the Kyrgyz Republic on the Use of Water Management Facilities of Intergovernmental Status on the Rivers Chu and Talas (Chu–Talas Commission)** was established in 2006 to implement the Agreement between the Government of the Republic of Kazakhstan and Kyrgyz Republic on the Use of Water Management Facilities on the Rivers Chu and Talas (2000). The Commission is supported by UN agencies and financial institutions (ADB, UNECE, UNESCAP, etc.).

The Chu-Talas Commission consists of Kazakh and Kyrgyz parties. The members of the Commission are appointed by the respective Governments. The Commission's sessions are organised at least twice a year. The Commission has a permanent executive body, the Secretariat, which holds regular meetings alternately in Kazakhstan and Kyrgyzstan. The Secretariat's major functions include the preparation of the Commission's meetings, administrative and organisational management and the preparation of annual reports. The Commission has established Working Subgroups on:

- legal and institutional issues;
- the allocation of water resources;
- waterworks and the reconstruction of facilities;
- economics, environment, monitoring and data exchange.

Bilateral commissions or other cooperation bodies similar to the above example have been established and are also in operation at other Central Asian transboundary rivers.

### **5.3. Integrated Management and Conservation of Water Resources of International Watercourses**

Water is a unique resource: rainwater and snow, river, lakes, groundwater – all these together form the water content in a river basin and make for the unity of water resources within the basin. To maintain the quality of natural water and to be managed effectively a basin should be considered as a coherent ecosystem to be monitored. This is reflected in the basin approach to water management.

The use of water resources requires coordinated local, national and regional actions in the river basins as intensive water use and water pollution as well as river facilities (dams, reservoirs, and canals) often change the hydrological regime, water quality and thus affect the conditions of water use.

Joint activities require reliable information based on the assessment of water resources, and in this regard one should note that the network of gauging stations in the Central Asian countries has dramatically reduced as the number of these stations has halved.

The International Glossary of Hydrology defines the assessment of water resources as the "determination of the sources, extent, dependability and quality of water resources for their utilisation and control". Water resources are defined as "water available, or capable of being made available, for use in sufficient quantity and quality at a location and over a period of time appropriate for an identifiable demand" (WMO, 1992). Therefore water resources assessment in a region, country or parts thereof is essential to

Country	Number of stations		2004 (as % of mid 1980s level)
	1980s	2004	
Kazakhstan	506	206	41
Kyrgyzstan	147	81	55
Tajikistan	139	89	64
Turkmenistan	38	31	82
Uzbekistan	155	131	85
Total	985	538	55

**Table 5.3**  
Gauging Stations  
in Central Asia

Source: WMO, 2005

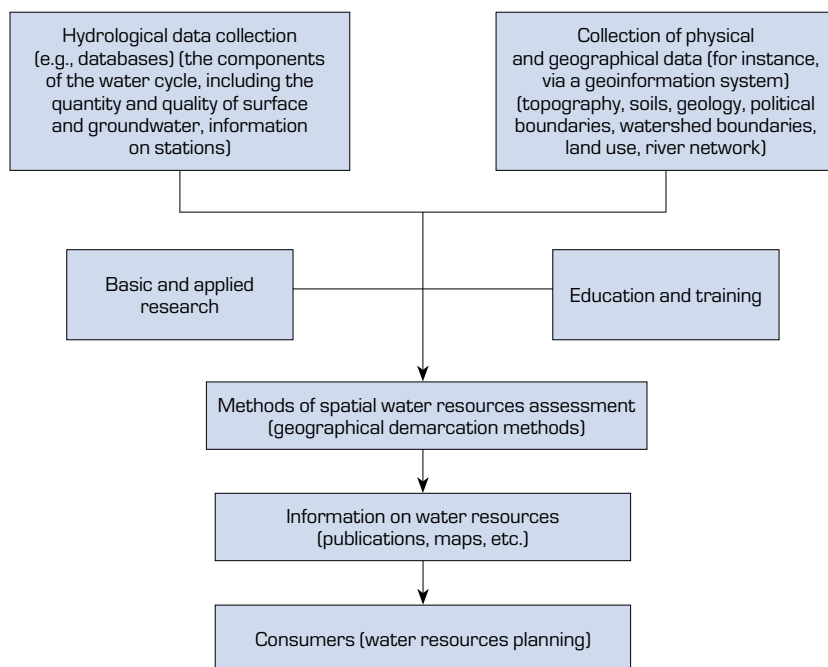
water resources planning and management in order to ensure reliable water supply and water consumption with respect to future needs.

Water resources assessment programmes, major components of which are given on *Figure 5.1*, will be different in each country depending on the needs and conditions prevailing in that country, however, in case of a transboundary river basin these programmes should have a common methodological basis in order to enable comparison of the assessment results and the use of these results in the planning of the use and protection of water resources. In general, the assessment of water resources includes the collection and processing of available hydrological and hydrogeological data as well as other auxiliary data required for spatial interpolation; this is required to assess the available water resources and in the development of national and regional long-term water resources use and research plans. These plans should take into account current and future needs in water resources and provide for the strengthening of interstate cooperation in this area.

River basin management should be aimed at the balanced development of surface and groundwater. Therefore the role of water resources use and conservation planning should increase at all levels: local, national and interstate levels. This helps to achieve objectives such as efficient water use, water distribution at local, national and interstate levels, and the environmental sustainability of river basins. The scarcity and vulnerability of water resources has called for a new approach to water resources assessment, development and management; this approach is based on the integration of water management plans and programmes.

Implementation of river basin management plans is about integrated water management; management should be based on water balances and integrated water utilisation and conservation plans. One should emphasise that a river basin management plan covers a shorter, as compared to programmes, period (from one to five years) to address water use and conservation issues.

Water balances help to link prospective water consumption with water resources. These balances are prepared regularly or from time to time broken



**Figure 5.1**  
The Components  
of a Basic Water  
Resources  
Assessment  
Programme

Source: WMO,  
1997: 5

down by river basins and administrative territories. Improved water supply usually requires streamflow redistribution and regulation, which is associated with reconstruction or the construction of new waterworks and facilities. Therefore water balances also help to plan investment in the water sector.

Water balances are prepared for a country, river basins or parts thereof. The stochastic nature of water resources predetermines the preparation of water balances for different scenarios of water sufficiency – for example, there may be a lack of water and water shortages, especially in the vegetation periods (for irrigated farming). Therefore water balances provide for water supply measures considering the permissible water withdrawal from a water source not just over the course of a year but also during the most stressful period, the vegetation period. A water balance includes inflows (surface water; groundwater not linked with surface water; and inflow from other basins) and outflows (water consumption from surface and groundwater, and water transfer to other basins). The comparison of inflows and outflows indicates either a shortage or an excess of surface and groundwater and based on that the relevant streamflow regulation and redistribution measures are developed. After these measures have been implemented the water balance is re-estimated.

Water resources in the balance are divided into surface and groundwater. The same approach is taken to water consumption. This is due to the differences

in consumer requirements for water quality, the need for a separate water supply, and water conservation - most notably, the conservation of groundwater. A water balance specifies items for streamflow redistribution. In addition to general water consumption a water balance also shows irretrievable water consumption. The difference between these shows the volume of polluted flow, which is the basis for planning clean-up activities. A water balance cannot be prepared without the development of refined water use rates and implementation of modern technologies designed to reduce water consumption and to apply efficient wastewater treatment techniques. Integrated water utilisation and conservation plans also provide for the preparation of water balances. This helps to improve the feasibility of long-term sectoral water supply plans, optimise water resources management and the composition of investment in water industry development – both country-wide and with respect to specific basins and areas.

The reason for developing integrated plans is to identify major water management strategies and other activities that need to be implemented in order to satisfy the water needs of the population and the various sectors of the economy as well as activities aimed at water conservation and to the prevention of adverse effects in the long run.

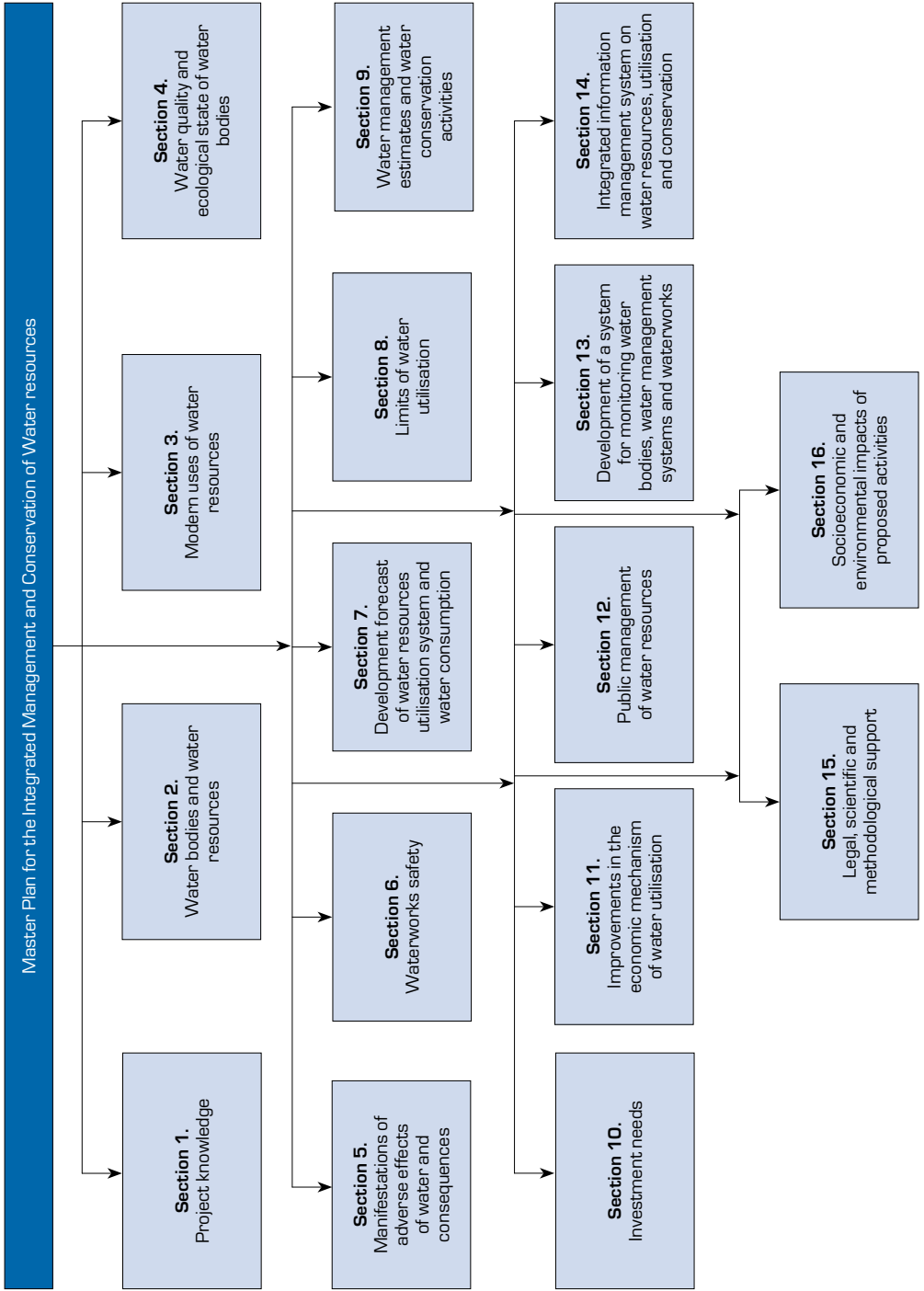
Integrated management and water resources conservation plans are the basis and the most important mechanism for the planning and management of water resources and enable the elaboration of common policies in river basins and the identification of practical measures to address water management issues in an integrated manner.

Plans are prepared for at least 15 years with a breakdown and justifications of the first phase by river basins in accordance with the country's water management zoning. The plans are classified as: master plan of integrated management and conservation of water resources; basin plans for specific river basins; and local plans covering provinces and districts, as appropriate.

A master plan for the integrated management and conservation of water resources provides a water management framework for the development of the national economy. It is prepared in mutual alignment with sectoral and territorial development strategies. The plan sets withdrawal limits and maximum permissible emissions of pollutants, water supply and use conditions for all water consumers, activities to maintain sustainability of river ecosystems at the national, basin and local levels. A master plan is based on basin and local plans where the key criterion is the unity of water sources and water consumers, and ecosystems as together these comprise the water-related economic system.

A master plan addresses water management issues country-wide and is prepared with a breakdown by basins of major water bodies.

**Figure 5.2**  
Suggested Content of a Master Plan for the Integrated Management and Conservation of Water Resources



A Master Plan reflects the national economic development strategy. Its major objectives are:

- to provide assessment of the country's water resources (surface and groundwater), broken down by river basins and an analysis of the current state and the technical possibilities for improved use (streamflow diversion, regulation, etc.);
- to identify the basic requirements of each sector (hydropower, fishery, agriculture, transport) for the water resources system, subject to the changes in water use patterns;
- to prepare prospective water balances, and thus identify areas with insufficient and excessive water supply;
- to forecast water quality, taking into account planned waterworks;
- to identify key water facilities to be constructed, both in the short and long-term;
- to outline the key activities required for water protection against pollution and depletion, as well as for the treatment and control of wastewater;
- to identify critical issues of water management development that require scientific justification in order to address them;
- to elaborate recommendations for the water resources factor to be taken into consideration in planning the development of economic sectors.

The activities proposed in the plans should aim to achieve the following:

- guaranteeing that both population and sector-specific water resources needs are satisfied, with a focus on utility and drinking water supply, the rationalisation of water consumption by industries, agriculture and the public utilities sector;
- the protection of people and facilities against floods and immersion in water, and the minimisation of the adverse effects of water;
- the reduction of the man-made burden on and pollution of water bodies, and the improvement of the ecological state of water bodies;
- the safe operation of water development facilities;
- the development of a system for monitoring, analysis and forecasting for water bodies, waterworks and facilities;
- an improvement in the public administration of water bodies; and
- the development of legal, regulatory, scientific and methodological support.

A Master Plan is prepared in a phased approach.

Phase I involves the preparation of a national strategy for the development of the water industry and water management; the strategy identifies major areas of public water management policies and water economy development for a projected period, based on the analysis of current use of water resources and ecological state of water bodies.

Phase II includes the preparation of the fundamental provisions of the plan with a forecast for the development of the water economy; this includes proposals for water use limits by water body basins and administrative areas (provinces) with a list of recommended water management and water protection activities, proposals for the financing of these activities (with appropriate estimates) and the improvement of the relationship between the economy and the use and protection of water resources, and proposals for improving the public administration of water resources. The fundamental provisions also include a concept note for an integrated information management system for the country's water resources and their use and protection, along with the analysis of information flows and proposals for data collection, processing, storage and output.

Phase III is where the Master Plan for the Integrated Management and Conservation of Water Resources for a projected period is finalised based on the strategy, indicators and feedback on the fundamental provisions.

The studies and estimates prepared during the development of Plans of Integrated Management and Conservation of Water Resources are formalised as books (volumes), annexes and databases. The following is the recommended structure for the Master Plan of Integrated Management and Conservation of Water Resources:

- abstract;
- Volume I. Executive Summary. This summarises all studies and estimates provided in the plan and contains systematised summary data for all sections of the plan;
- Volume II. Integrated Water Management and Protection Information Management System. This includes a description of the information management system (structure, content of databases, information sources, information flows, interagency data exchange regulations), and summary output tables, as well as instructions for software use;
- annexes, including:

“Water Resources Development and Water Consumption Forecast”. This provides analysis of current uses of water resources, future development forecast, water requirements, and proposals for water consumption limits for administrative areas (provinces);

“Water Management and Conservation Activities”. This annex should include a summary list of water management and water conservation activities (with cost estimates and capacities) that are contained in specific programmes and basin plans; summary indicators of investment needs and research needs, other costs with a breakdown by activities, financing sources, ministries and agencies.

A Basin Plan for the Integrated Management and Conservation of Water Resources is prepared on the basis of a Master Plan for the Integrated Management and Conservation of Water Resources. It covers a river basin of surface water bodies and is prepared with breakdowns by administrative areas (provinces), water resource areas and sites. *Picture 5.3* below demonstrates the sections that should be included into a basin plan.

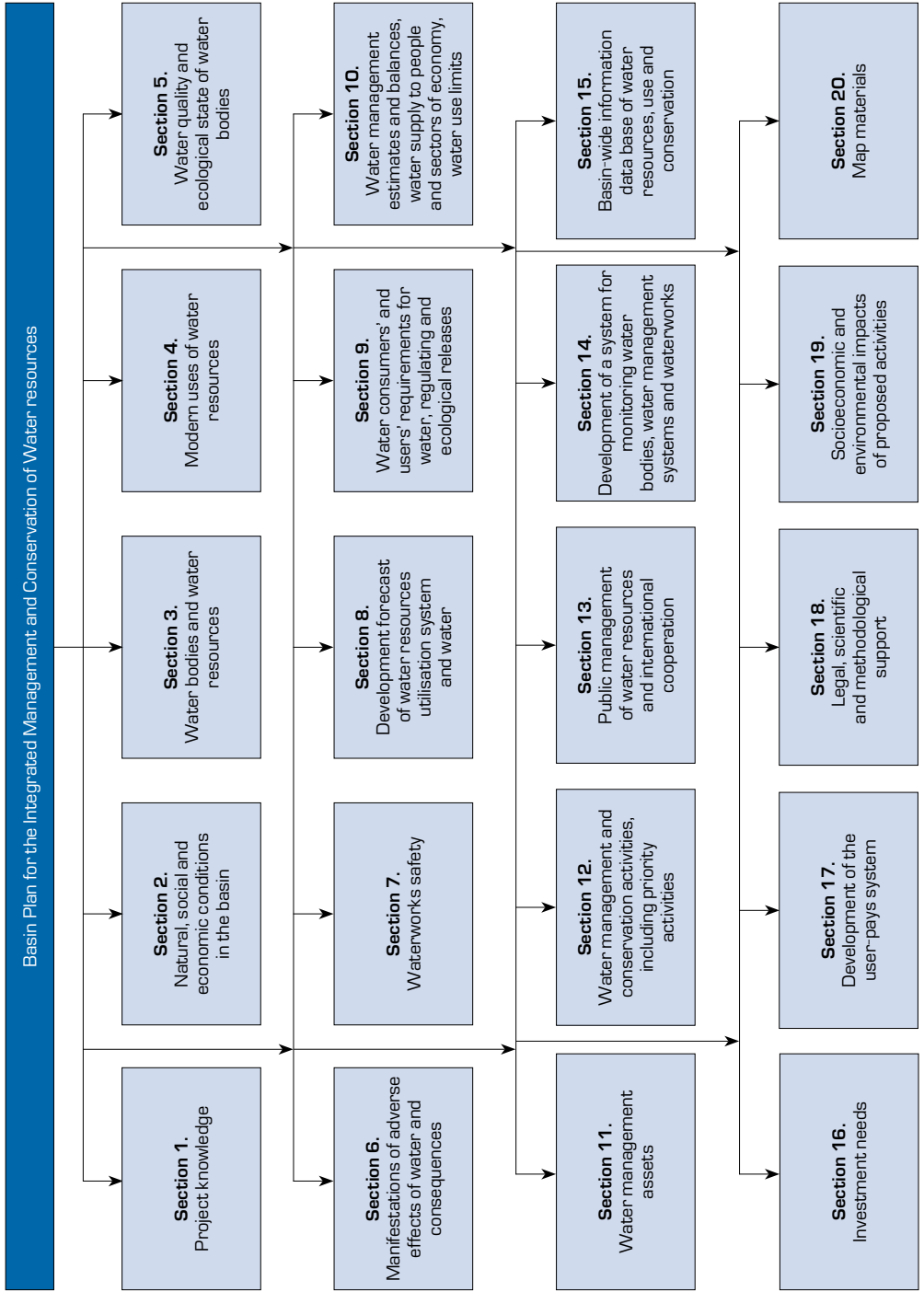
The objectives addressed by transboundary river (water body) basin plans result from the requirements of intergovernmental agreements, treaties and protocols. These objectives address transboundary issues: the distribution of water resources in transboundary river basins, flood control, the transboundary transfer of pollution, and contingency relationships. To address the above issues basin plans specify the proposals for use and protection of transboundary water bodies, the development of monitoring and information sharing systems, the alignment of water legislation proposals on the development of standards, scientific and technological cooperation as well as on the joint development of intergovernmental programmes and projects.

Basin Plans are prepared in two phases.

Phase I involves the preparation of the fundamental provisions of the Basin Plan. The provisions should cover the analysis of water management and environmental issues in the basin and the proposed ways of addressing these issues, the proposals for water use limits, water management and water conservation activities, and the improvement of the relationship between the economy and the use and conservation of water resources in a water basin, including proposals on water use charges. The fundamental provisions should also include a concept note for the basin-wide information management system as a component of the public administration of water resources in a basin.

Phase II includes the elaborate the Basin Plan per se based on the proposed fundamental provisions and the feedback on the provisions. If necessary, further phases in the development of the Basin Plan can be added, subject to specific objectives specified in the relevant Terms of Reference. In particular, the development of a basin-wide information management system, water management estimates and balances and implementation of specific software can become separate phases. The national water

**Figure 5.3**  
Suggested Content of a Basin Plan for the Integrated Management and Conservation of Water Resources



management authority is responsible for the development of the Master Plan whereas Basin Plans are prepared by the basin water management authorities.

The recommended structure for the Basin Plan for the integrated management and conservation of water resources is:

- abstract;
- Volume I. Executive Summary. This is a summary of all studies and estimates provided in the plan and contains systematised summary data for all sections of the plan;
- Volume II. Basin-Wide Information Management System of water resources, their use and protection. This includes a description of the information management system (structure, content of databases, information sources, information flows, interagency data exchange regulations), and summary output tables, as well as instructions for software use;
- annexes. Given that basins of water bodies as well as the objectives to be achieved may significantly differ, the content of annexes for specific water bodies can be defined in the process of developing the plan.

The following structure of annexes to a Basin Plan is recommended:

- “Water Resources Development Forecast and Water Requirements”. This annex should include an analysis of the current uses of water resources, future development forecast, and water requirements;
- “Water Resources, Water Management Estimates and Water Consumption Limits”. This annex should provide a detailed description of water bodies and water resources, methodologies and outputs of water management estimates and balances, the results of the statistical treatment of water management estimates, an assessment of water availability for water consumers and water users, and the proposals for water consumption limits for specific large water consumers;
- “Water Quality and Ecological State of Water Bodies”. This annex should address the issues of surface and groundwater quality, pollution sources, and the current ecological state of surface water bodies; it should also provide projections of changes in the water quality and ecological state of water bodies as a result of the proposed water management activities. The annex should provide justifications for ecological and regulating releases;
- “Water Management and Water Conservation Activities”. This annex should include justifications with all necessary estimates for the proposed

water management and water conservation activities. It should provide proposals for funding sources (depending on the jurisdictions).

The Regional Plan is prepared on the basis of the Master Plan of Integrated Management and Conservation of Water Resources and Basin Plans as well as for specific subnational entities (provinces), water resource areas and areas of specific river basins. The preparation of Regional Plans involves almost the same activities (sections) as for Basin Plans, with the exceptions of Sections 13 and 15.

Scientific and methodological support for the preparation of Master, Basin and Regional Plans is provided by the national water management authority. Various ministries and agencies are involved in the preparation of integrated management and water resources conservation plans. These include authorities in charge of hydrometeorology, geology, environmental protection, health, agriculture, energy, fishery, transportation, economy and finance, construction and regional development, statistics and information, land surveying and mapping, border protection, local governments and some large enterprises, irrespective of the ownership. In the case of a transboundary river basin, the Foreign Ministry should be involved as well because its plan usually provides for drafting of agreements on various issues surrounding the shared use and conservation of water resources with neighbouring countries. The national water management authority plays an essential role in the coordination of these activities.

Plans provide for considerable scope of work and activities, which necessitates processing and storage of large amounts of data (the content of plans of integrated management and conservation of water resources can be found in the annex). In fact, the plans cover all issues concerning water use and water consumption by industries and people, as well as long-term conservation issues. The development of plans therefore requires the establishment of a data bank and a system to manage it appropriately. This should be continuously updated to enable the national water management authority to prepare and subsequently implement river basin management plans on the basis of the information management system.

The activities in the plans are aimed at the sound use of water resources and the improved sustainability of water supply to people and economic sectors. The proposed activities provide for improvements in production methods, application of low-water and water-free processes, and reductions in non-recoverable water losses in irrigation and water supply systems. Measures are proposed for water regulation through inter-basin streamflow redistribution as well for reductions in uncontrolled waste disposal, and the prevention of inundation and water-logging of towns and villages, agricultural land and other facilities. Based on assumed scenarios of water consumption and water

discharge the plans specify lists of waterworks that will secure future water needs and maintenance or renovation to achieve the required water quality as well as major technical and economic indicators for the projects accompanied by an outline of sources of funding.

The legal framework for cooperation among Central Asian countries in the subject area is set by the CIS and EEC agreements and the water legislation in each country in the region. For instance, the Water Code of Kazakhstan (2003), Article 46 “Integrated Management and Conservation of Water Resources Plans” specifies that these plans should be prepared for integrated water resources management decision-making. The plans are prepared by water management authorities, financed by the national budget, with the involvement of research and specialised design entities and the relevant government authorities. Article 61 “Scientific and Information Support for Sound Use and Conservation of Water Resources” provides for the establishment of the national water use information analysis system. Article 143 “Arrangements for Cooperation in Transboundary Water Use and Protection” covers in detail major areas of information cooperation, which include:

- the development and alignment of monitoring programmes for transboundary waters and water bodies and participation in implementation thereof;
- joint financial and technical participation in the management, regulation and protection of transboundary waters;
- sharing information on water resources in transboundary river basins, and prompt notification and mutual assistance in water-related emergencies;
- cooperation with neighbouring countries in the area of the unification of the regulatory and legal framework, the creation of joint monitoring systems, the development and implementation of joint transboundary waters protection and recovery programmes and related environmental systems, and the mobilisation of funds from international organisations for the afore-mentioned purposes;
- the development, alignment and implementation of activities for the joint management of transboundary waters and waterworks;
- the establishment, if appropriate, of an interstate transboundary water management authority for the joint implementation of the interstate and intergovernmental agreements on transboundary water use and protection that have been ratified by the Republic of Kazakhstan;
- the creation of regional and national databases on transboundary water use and protection;

- the pursuance of joint research to address water issues.

The Water Code of Kyrgyzstan (2004) provides for a basin approach in water management (Article 5) and the development of programmes and requirements for the preparation of basin development plans, water resources use and protection in each major basin (Article 20).

A Basin Plan:

- includes a risk assessment of low water, droughts, floods, pollution and dam failures in the basin and cost estimates for risk prevention, mitigation or recovery;
- identifies areas where there is a risk of pollution sources;
- contains a review of existing protective zones;
- identifies locations where there are risks of floods and mudflows as well as activities to be prohibited or limited in those locations.

Additionally a basin plan may:

- include an assessment of water quantity and quality within a basin;
- identify existing and potential water requirements for different uses;
- identify water reserves for additional use subject to environmental requirements and international commitments;
- identify water requirements for environmental purposes and for the population;
- assess investment and financial needs, along with identification of potential financial sources;
- set water use priorities and potential limitations of water users' rights in different economic sectors;
- identify locations where bank protection dams need to be constructed to protect agricultural land and where forestry needs to be cultivated;
- identify locations where gravel and other materials can be produced.

The information services for water management activities are regulated by Articles 93, 94 and 95 of the Water Code; these articles provide for the development of an integrated information management system for water and the reclamative state of irrigated land.

In the Water Code of Tajikistan (2000) issues surrounding water protection planning are regulated by Article 122. This article directs that water protection activities should be included in forecasts of national economic and social development based on the plans for integrated water management

and water resources conservation in river basins and the country as a whole, as well as long-term national and subnational development and local programmes and plans. Article 134 provides for planning water distribution among water consumers with due consideration of the satisfaction of drinking and domestic water needs as a priority, water protection and the prevention of adverse effects of water. According to Articles 135 and 136 the national water inventory and national waterworks inventory of Tajikistan represent official data population on the State, the utilisation and protection of water bodies and systematised data on waterworks.

Tajik water resources utilisation database and information management system should be established for the purposes of long- and medium-term planning of integrated management and conservation of water resources and information support for water management authorities (Article 137). Article 139 provides for the development of the Master and Basin Plans of integrated management and the conservation of water resources; these plans are to identify major water management and other activities to be implemented to ensure the satisfaction of the future water needs of the population and the national economy, as well as for water protection and prevention of the adverse effects of water.

The Water Code of Turkmenistan (2004), specifically Article 10, provides for the development of national, interstate and regional water utilisation and protection programmes; these programmes are developed to implement meaningful and effective activities for the satisfaction of the water needs of the population and the economy, for water conservation, sound use and water resource protection and the prevention of adverse effects. Articles 101 and 102 provide for the preparation of water balances that assess water availability and reliance in river basins, water management zones and country-wide, as well as for the preparation of Master and Basin (Local) Plans for the integrated management and conservation of water resources. These plans identify major water management and conservation activities that will satisfy the water needs of the population and the economy, to ensure efficient and sound use of water resources and to protect water resources and to prevent the adverse effects of water. Pursuant to Article 103 of the Water Code the planning of water utilisation and protection shall provide for science-based water distribution among water consumers with the priority being the satisfaction of the drinking and domestic water needs of the population.

The Uzbek Law on Water Consumption (1993, as amended as of January 1, 2011), in a special Chapter, including Article 83 and 84, identifies the issues surrounding interstate water consumption in the Aral Sea basin. These articles say that the regulation of transboundary water bodies (Amu Darya, Syr Darya, Zeravshan, Aral sea and other transboundary water bodies)

located in the Republic of Uzbekistan and other states of the Aral Sea basin is subject to the international treaties that Uzbekistan is a party to, as are water consumption and use and water management and conservation activities on transboundary water bodies. Articles 108, 109 and 110 provide for water use planning, the development of the national water resources inventory and water balances for assessment of availability and reliance of water resources. Article 111 provides for the development of Master and Basin (local) Plans for the integrated management and conservation of water resources to identify major water management and other activities to be implemented to satisfy the future water needs of the population and the national economy as well as for water protection and the prevention of the adverse effects of water.

Plans are prepared by a number of highly qualified specialists in various branches of knowledge and the economy and there are strong arrangements for research and design activities. It should be therefore emphasised that in the Soviet times there was a large network of design organisations having different specialisations and sectoral subordination. Design organisations performed a large amount of design work, prepared development plans, elaborated regulatory and auxiliary materials on designing and construction; prepared estimation standards; and performed field supervision of construction projects. Design organisations were in many cases affiliated with research institutes and laboratories. Many design organisations had the status of lead agencies for the development of regulatory documents – Construction Rules and Regulations – that were approved by sectoral ministries or the standardisation authority. The availability of these organisations and highly qualified design specialists in the national and subnational water management authorities allowed for the development of the USSR Master and Basin Plans for the integrated management and conservation of water resources, as well as the relevant plans for the Soviet republics and all river basins. Hence, a unique database was created which became the basis for plans for the integrated management and conservation of water resources prepared during that period.

After the Soviet Union collapsed and at the time of economic reforms, water sector research and design organisations in the CIS countries, including in Central Asia, were reorganised into cooperatives, partnerships and joint stock companies, i.e. they were removed from the public sector. As a result, many of them were divided into smaller entities or collapsed, or shifted to other, non-core activities. Reduced investment activity in the economy triggered the contraction of new construction, reconstruction and upgrade of power facilities and hence further reduction in the scope of research and design activities and the number of design organisations. Numerous reorganisations in the management structures, the accelerated denationalisation of design and research organisations and the loss of considerable scientific and technical

information, project designs, and research materials – these are negative factors that affect national and regional security. The water development facilities in Central Asia are worn out and obsolete and require urgent measures to be taken for the facilities to be reconstructed and upgraded. The lack of historical materials in these cases prevents timely arrangement of activities at the facilities, which in turn threatens water supplies to the population and economic sectors.

There is no strong design services market in Central Asia; normally the market would offer high quality services and enable these to be put in to use. In the region in general, there is still no well-developed effective system of design organisations; this is not just the case in the water development sector, but in almost all other sectors of the economy as well. The role of state should be clearly defined in strengthening the design and engineering sector, in maintaining a stock of project designs irrespective of a designer's status and ensuring access to these. It should be specially noted that the inflow of young specialists into the design sector has almost ceased as no relevant training is provided by educational institutions in Central Asia. It takes about 15-20 years for a specialist to become highly qualified. The current negative situation with staffing in the Central Asian water sector may result in the contraction of investment activities in the water sector and in other related sectors as well.

Plans for the integrated management and conservation of water resources outline the perspectives of sustainable water supply in a country, river basins and regions and as a result are the justifications for developing investment processes in the water sector in the long run. These plans provide the basis for making decisions on water infrastructure development and should be considered as key components in the investment process.

The development of plans for the integrated management and conservation of water resources may take several years and its duration, complexity, costs and the involvement of many specialists and scientists from various scientific, technical and economic areas is comparable with the development of a megaproject. This is a very important phase of the investment process, which underlies the long-term development of water management in a country, a river basin or an area.

The issue of scientific, research and design support for water management development is extremely sophisticated and multidimensional. It requires interstate efforts and the efforts to address this issue are among the areas of cooperation between and among the Central Asian countries. Due to the lack of specialists and the abrupt reduction in design organisations, the activities for the preparation of plans for the integrated management and conservation of water resources have ceased in all CIS countries.

Even if in some countries plans (or something similar) are prepared, they tend to only partially consider river basin issues. These plans usually are not linked with long-term national development strategies. The CIS countries, including those in Central Asia, that share river basins, have no joint efforts in the development of transboundary river basin plans and in their relationship the parties still rely on the materials prepared during the Soviet period. First and foremost for the data on hydrological regime of rivers and the water resource assessments. Though the plans were prepared some 20-30 years ago and some of them have become outdated, the value and importance of the materials contained in these plans is still significant. The requirement to regulate the issues surrounding the water relationship among the countries of the CIS' transboundary river basins, including the Central Asian states, and the development of hydropower and other water uses necessitate objective and reliable data on the sufficiency of water supply and prospective increases in water consumption, which, in turn, justifies the joint preparation of plans for the integrated management and conservation of water resources.

The water sector in Central Asia is facing serious difficulties; the upgrade of obsolete infrastructure requires large investments, planning of activities and the preparation of design documentation. The content of earlier plans for the integrated management and conservation of water resources demonstrates that water development projects require a large amount of information and access to it, which implies the need to interact with many management authorities and organisations at local, national and interstate levels.

Unfortunately, these authorities are generally of low quality in Central Asia, and there are no communication arrangements, and this impairs the effectiveness of planning and justifications for project solutions and entails considerable economic loss. For instance, as reported by the U.S. National Institute of Standards and Technology, the U.S. economic loss due to insufficient joint effort in information cooperation during investment projects was as high as \$15.8 billion per year (Deloitte, 2012). This demonstrates the need for effective cooperation in the planning of water management activities and designing water facilities.

Water management and hydropower projects appear to be some of the most capital-intensive projects compared to other sectors. Therefore risk reduction and successful project implementation require clearly defined and auditable business processes and careful planning. This is the basis for successful implementation of a programme. Risk reduction in large investment projects for construction of water management and hydropower facilities requires access to reliable and up-to-date information irrespective of time or location. Ensuring access to relevant information will likely become one of the major issues to be faced in the future in the process of designing and implementing investment projects.

The background materials of plans for the integrated management and conservation of water resources should be the fundamentals of these activities. It should be noted, however, that the materials of these plans have become outdated and have not been updated. The Central Asian countries also face some very specific difficulties in developing their programmes; these include the issue of access to baseline information, its limitations and non-reliability, a lack of highly qualified specialists and the poor equipment capabilities of design organisations.

The format for storage and use with possibilities for electronic transfer of data becomes especially important. Most of the existing water management facilities were constructed on the basis of paper drawings and documents that should now be digitised and a database should be established with remote access to it. The information should be stored not just during the construction phase of a facility but throughout its operational life as well. Improved information cooperation among countries in the region regarding water resources planning and use would facilitate the identification of feasible perspectives for the development of the national and regional water management infrastructure and reduce competition for water.

There are two large types of infrastructure: economic and social. Economic (or production) infrastructure includes transportation, communication, power and water supply. In its turn, social infrastructure covers education, health care, utilities, cultural and recreational assets. Water sector infrastructure is unusual as the division in infrastructure is quite nominal in that it has both economic and social importance. The water sector infrastructure has different effects on long-term economic development both as a direct production factor and a social element of other production factors and the living environment of the population. As a production factor the infrastructure is considered in terms of its direct contribution into operating processes. As a social factor it is considered as a necessary condition for human development and improvement of health and safety as it contributes to improved water supply and sanitation. Investments into the water sector are important tools for agricultural, energy, industrial, social and environmental policies.

Infrastructure investments are usually considered to be essential vehicles of economic development and in the creation of new jobs. As is the case in any country, most activities in the infrastructure sector take place within the national borders, and so infrastructure investment appears to be an optimal solution to the issue of the redeployment of resources and workforce, from sectors that are facing development slowdowns to sectors that can enable long-term economic development. It has been proved that an increase in accumulated capital in this sector facilitates GDP growth; each dollar invested into infrastructure projects has a multiplier effect of \$1.59. It has also been

noted that \$1 billion of infrastructure investments creates 15,000 direct jobs and about 30,000 additional jobs in related sectors (Kondratyev, 2011: 18-24).

When preparing a strategy for infrastructure development and upgrade in order to achieve gains in productivity and competitiveness any country faces a number of issues. First and foremost, is the issue of priorities. Given the limitations in financial capacities and the deterioration of the infrastructure the choice of priorities is of paramount importance. The water sector infrastructure is the most important long-term investment object for any country; investment in this sector predetermines the quality of human life and the economy 20–30 years into the future. Therefore the need to create an effective mechanism to use investment sources is evident. As infrastructure has been and will continue to be a public good, irrespective of how its elements are controlled, or whether these are public or private investments, infrastructure projects should first meet public needs. This is the case when there is public supervision of the design, financing, construction, operations and maintenance of these facilities. The significant risks related to corruption and ineffectiveness of decisions made that are faced by infrastructure projects should be taken into account. Thus, for instance, some expert estimates demonstrate that due to corruption and bureaucratic barriers the construction of 1 km of a highway in Russia costs 2.5 times more than in the U.S., 3.5 times more than in Brazil and 4 times more than in China. Clearly, a similar situation can also be found in Central Asia. Another group of risks pertinent to the implementation of infrastructure projects is the threat of inflation (Kondratyev, 2011).

Subsidies are widely used in the EU for investment in water resource infrastructure and government support is provided to cover investment costs in this sector (OECD, 2006: 100). In Austria, for example, financial assistance of up to 70% is given for the construction costs of new water treatment plants and 15% for new municipal water supply systems, which are made through lump sum subsidiary payments for decentralised water supply projects. The financial products available in Austria for these purposes include interest subsidies and grants. Project costs in Belgium that are accrued from projects carried out by Aquafin (Belgian company) are partially covered with assistance from the MiNa fund, and Aquafin has to attract the additional funding from national and international lending institutions. Investment programmes and projects in water supply infrastructure are regularly audited both internally and externally. France also provides financial assistance for these purposes (up to 40% of the cost of new water treatment plants) with additional funds (up to 20%) in loans. Financial products available in France for the development of the water supply infrastructure include grants and soft loans. German financial assistance comes in the form of soft loans of up to 66% of the investment costs for new water treatment infrastructure. Assistance

under the loan programmes for local authorities may be used in conjunction with other funding sources.

The agreement between governments/agencies and the executor of the programmes and projects, as a rule, includes the appropriate provisions to ensure that project targets are achieved and that programme managers take responsibility for their decisions. In most countries, revenue collection and public procurement are clearly separated from the professional management of costs. Disbursements of financing resource programmes are made using basic mechanisms such as grants, soft loans, and interest subsidies. These financial products are compliant with the potential of the implementing agencies, especially when banks are responsible for the risk assessment and for proper controls over the loans granted.

It is worth noting that the system of state support for developing the water and sanitation systems in each country is undergoing major changes. Originally, the management of government subsidies was carried out under the supervision of the relevant government bodies. Over time, pressure on these government bodies was partially reduced due to the involvement of non-governmental (sometimes private) agencies in the institutional design of subsidy management or by transferring the respective responsibilities to them. For example, commercial banks play a major role in Austria, managing the federal government's environmental expenditure scheme. In 1993, the Austrian government transferred responsibility for the management of the subsidy programme for water and drainage infrastructure to Kommunalkredit Austria GmbH bank. In Belgium, a public-private partnership was designed for the management of the government's investment programme in water treatment at a regional level. The executing agency (AquaFin) is responsible for the implementation of the investment programme and the construction and operation of the drainage system. After the duration of the management agreement between the executing agency and the government completes (2020), all assets will be donated to the government. In France, the water agencies (Agences de l'eau) represent the country's main river basins, with each agency being responsible for the water management of a particular river basin. They receive revenues from payments for pollution and water withdrawals and they also make decisions about revenue distribution for investment in the water infrastructure. The municipalities are the main beneficiaries of this system, but support is also given to industry and farmers.

Water infrastructure is an important factor in the formation of aggregate demand. Major infrastructure projects are usually accompanied by significant investment in the construction of water facilities and structures and later in their repair and reconstruction. This creates a demand for related industries (metallurgy, manufacturing of construction materials, contractors and

machinery, and services like educational, research, and project design). The government often uses these projects as a mechanism for developing crisis management policies or to achieve specific objectives in economic growth. Moreover, investments in water infrastructure may be used as tools for agriculture and industrial policy, where the state implements specific projects and encourages private capital to participate in the process. Thus, the construction of water lines, reservoirs, canals, and small HPP in rural areas can attract private sector funding and in general, accelerates economic growth in rural areas. To maintain the infrastructure sustainability of the economy requires a certain amount of investment. For example, modelling the relationship between investment in infrastructure and GDP in 52 countries from 1980 to 2002 showed that in order to maintain GDP annual growth rates at 3.6%, investment in electricity and telecommunications should be 0.2% and 0.7% of the GDP, respectively. In order to achieve 6% annual growth, these figures double (Kondratyev, 2011).

With regard to Central Asian countries, annual investment in water infrastructure, including both urban and rural water supplies and taking its current poor condition and high degree of wear and tear into account, should not be less than 2.5-3% of GDP. The issue of the relationship between the construction of new water infrastructure and the repair of the existing system is of fundamental importance, but its solution is complicated by the lack of methodologies with which to assess the existing infrastructure and the extent of its depreciation.

#### **5.4. Transboundary Water Body Management: Central Asian Road Map**

With the formation of new independent states, the geopolitical changes in CA necessitate an update to the existing (and perhaps even creating new) organised forms of joint management of the transboundary river water resources in Central Asia. These should be based on international law and international best practices in transboundary river basin cooperation.

As far back as the 18<sup>th</sup> century, attention was paid to the special and specific properties of water resources that were then the basis for considering river basins as a single natural and geographical location and the consequent need to resolve legal interests of one or another sides in the river basin. Because of this, the modern concept of integrated water resource management was subsequently formed. Thus, Dingelstädt V.E. showed that "... flows – that is, continuously moving waters – have a completely different character. They should never be considered as an object of property as long as they maintain their connection to its fountainhead and the live streamflow is unbroken. Water is such a great treasure for man and it is quite natural that in issues of water use, dissenting interests arise. Resolving the differing interests must comply with permanent rules and must

be the subject of water legislation. States, public and private interests, old and new enterprises and establishments, agriculture and industry, irrigation-dependent enterprises, drainage-minded enterprises, etc. may compete among themselves” (Dingelshet, 1880: 45-46).

CA water body management is based on the basin principle, which allows the comprehensive regulation of the use of water resources from the Aral Sea basin in line with its limitations. To this end, regional basin water associations (BWA) were created in 1987 along the Amu Darya and Syr Darya Rivers and the control over all State head water facilities at these rivers and their tributaries with flows above 10 m<sup>3</sup>/s were transferred to these associations.

The regulation of the use of water resources is carried out by the BWA based on the rules and schedules of the reservoirs operating regimes and the water withdrawal limits agreed between the republics and the then Ministry of Land Reclamation and Water Management of the USSR.

As noted, in Central Asia until 1992, the centralised interrepublic water resources management mechanisms functioned effectively. The operating regime of hydro stations was also under centrally supervised management and was in agreement with (or even obeyed!) solutions to the problems of regional water use and long-term river flow regulation for the sustainable operations of the economy’s dominant agricultural sector, which is based on irrigation farming, and the safe passage of water into the lower reaches of rivers in the winter-spring period.

During the USSR, the issues surrounding integrated water resource management were addressed using a single system approach, namely:

- a financing system that provided for a multi-purpose waterworks system funded by shared interest from various industries in proportions determined by calculations;
- the application of general and individual criteria of national economic performance determined by the priorities of specialised industries, in particular cotton;
- the operation of compensation mechanisms. Loss of energy from the various Soviet republics tied to the work of waterworks facilities in the irrigation regime was provided for with off-season flows of electricity between HPP and TPP with the operating modes between them having been properly organised.

Supranational bodies were represented by the Soviet Union ministries, coordinated by the Union government, and provided effective interstate communication in the water-energy sector, supported by an optimal fuel-

energy balance in each republic, thus creating the conditions for regulating the energy supply and, accordingly, interstate water allocation. Today, this interaction could be called a hydropower swap scheme.

After the USSR collapsed and the newly independent states were formed, they turned away from this economic scheme, which led to complex problems in managing the energy systems at a regional and national level. The collapse of the Soviet Union government and the cessation of activity by the hydropower regulating bodies in the Syr Darya and Amu Darya transboundary river basins threatened to disrupt the established order of water use and the likelihood of tensions in the water relations between the Central Asian countries. The most optimal solution to the problems that have arisen could be for the CA countries to themselves maintain the basic functions of the former Soviet Union bodies that regulated and distributed the hydropower resources at an interstate level. Understanding this need led to the CA countries signing an intergovernmental agreement on the establishment of the Interstate Commission for Water Coordination (ICWC) on February 18, 1992. Its membership includes the heads of the water management organisations from the five participating countries. The working bodies of the ICWC became the basin water associations – Syr Darya BWA (Tashkent, Uzbekistan) and Amu Darya (Urgench, Uzbekistan), the scientific-informational centre (Tashkent, Uzbekistan) and the Secretariat (Khojand, Tajikistan). In March 1993, the ICWC became part of the International Fund for Saving the Aral Sea.

Despite the fact that the ICWC is entrusted with deciding almost all of the issues concerning interstate water allocation, in reality, this body does not have the necessary legal and economic capabilities. The main drawback of the existing organisations (both water and energy management) is that they interact weakly with one another even at the national level and their actions are compartmentalised. Solutions are, for the most part, dictated by short-term political and economic benefits and do not involve multiple aspects of improving the sustainability of future water use or the relationship between water and hydropower infrastructure. The absence of a regional legal and economic mechanism in the water-energy sector prevents the problems of joint use of the transboundary rivers from being solved.

Instead of a coherent approach to a more efficient use of hydropower potential of the overall river basin, each country has developed its own strategy for water use. This leads to increased competition for water, thereby worsening water scarcity and expanding large-scale environmental problems both domestically and regionally.

The lack of a legal mechanism between the countries to resolve issues surrounding interstate water and hydropower facilities located on transboundary bodies of water has become one of the main obstacles in

creating a regional hydropower consortium. This has been a topic of discussion for several years, but the long and numerous consultations with international organisations have not yielded positive results.

In the upper reaches of the rivers, water is a hydropower resource whereas in the lower reaches of the river, it is primarily seen from the perspective of irrigated agriculture and food security. However, the problem of water use under specific circumstances in Central Asia cannot be resolved unilaterally in favour of one sector or another of the economy as it is comprehensive (integrative) in nature. All of the bodies of water in CA were planned to be part of an integrated system – mostly the reservoirs with large HPP that have interstate significance. Their operational rules account for multiple types of water use and the relationships between them. Unfortunately, modern water policy, laws, projects, rules, and administrative actions of the countries in the region rarely take into account the complex nature of using water resources. In practice, they usually try to organise and manage the activity of individual sectors of water management. The problem of managing surface water resources and maintaining the quality of water frequently belong to various departments and fall within the responsibilities of agencies that have conflicting interests. One agency is responsible for irrigation, another for the water supply and sanitation in bodies of water, while a third for hydropower and yet another for environmental policy, and so on. This fragmentation leads to uncoordinated decisions independent of one another. The same source of water in different circumstances is planned for different and competing water use, creating complex situations. Therefore, it is necessary to move towards integrated water resource management, which not only take the water needs of various sectors into account, but also provide for a balanced use of water and avoid disturbing the sustainability of the river ecosystem.

There is an important relationship between emergencies on the transboundary rivers and the strengthening of regional cooperation in the area of water resource management. Risk management for transboundary floods or water shortages should be viewed as part of the plan for integrated water resource management and take into account the safety of waterworks, sanitation and environmental safety, the sustainability of water use in the region during emergencies. That is why bilateral and multilateral cooperation should be promoted in the transboundary river basins, and these will reinforce one another (UNECE, 2009: 52-53).

Determining problems together and having a common understanding of the interests of all countries is necessary in order to strengthen cross-border cooperation. The basis for cooperation lies in laying out a risk management cycle for floods or water scarcity: information on past emergency hydrological situations should be assessed, documented, recorded, and communicated to

other countries. To properly address issues of flood management or water scarcity, all the concerned parties should participate. Joint programmes that raise public awareness and involve the public in the decision-making process could become a basic component in cross-border cooperation.

Experience from countries located in transboundary river basins indicates that sustainable water resource management and the development of their potential can be effectively implemented at the regional (basin) level. The most optimal solution would be the creation of a joint river basin body with representatives from high government bodies of the parties with clearly defined rights and responsibilities. In countries with transboundary river basins, as a rule, international basin organisations with broad consultative and regulatory powers and access to funding resources for implementing basin development plans generally already exist.

The growing shortage of water resources and the expected growth in water demand are potentially responsible for the political and legal conflicts among countries that jointly exploit water resources. Developing legal mechanisms for joint water resource management that take international experience into account should be the basis for resolving the numerous contradictions in the use of water resources at both the regional and national level.

Despite efforts to improve the effectiveness of hydropower regulation in Central Asia, carried out as part of the integration of organisations and regional structures (with support from international organisations), the problem of rapprochement among parties remains unresolved. Given the rules of international water law and the specific conditions in the Aral Sea basin, the following basic principles of interaction among the Central Asia states in hydropower regulation are suggested:

- mandatory implementation of decisions;
- mutual benefit to all parties of the hydropower regulation;
- efficient problem solving;
- follow the basic principles of international water law, agreed on by the states of the Aral Sea basin relating to the specific conditions of the region;
- synchronisation and harmonisation in solving hydropower regulation issues and investments in energy development;
- the responsibility of private business (in the event of its participation in investment and regulation) to ensure agreement at the international level of reservoir and power system operating regimes and energy supplies;
- interrelation between water and energy regulation;

- ensure environmental safety;
- creation of a guarantee fund with contributions of all parties for carrying out obligations;
- joint ownership of hydropower facilities of a transboundary nature;
- the formation of joint water and energy balances;
- the creation of joint management and permanent executive bodies with adequate authority for resolving disputes.

The mechanisms for interaction provide a system of measures of an economic, technical, institutional and political nature. Economic mechanisms include the implementation of joint investment projects, mutually beneficial participation in hydropower regulation, with the creation of joint ownership over objects of transboundary importance.

In terms of technical and technological cooperation in CA, there is an adequate institutional framework of functioning executive regional energy and water management structures. These include the UES CA coordinating council, the Energy Coordination and Control Centre, the International Fund for Saving the Aral Sea with an executive committee that includes an Interstate Commission for Water Coordination (ICWC) and the Interstate Commission for Sustainable Development (ICSD), the Science-Information Centre of the ICSD, the Amu Darya and Syr Darya basin associations (BWAs), and the Research and Information Centre of the ICWC. These bodies execute the bilateral and multilateral decisions made by the Central Asian states. But the interactions of regional structures are not of a systemic nature, and interagency and interstate agreements on the operating regimes of hydropower plant cascades and power system are not up to par.

The complexity and diversity of problems faced in the use of the water resources of the Syr Darya and Amu Darya transboundary rivers, the importance these have to the functioning of all sectors of the economy, and to the environment at a regional scale require a sequence of actions (a road map) to improve the management of the water body.

Currently, there are limited electricity swaps between CA states as well as electricity exports and other energy supplies outside the region. As a result, the operating regime of the Naryn-Syr Darya reservoir and the Vakhsh HPP cascade to a greater degree correspond to the upper reaches of the rivers. The nature of this relationship reduces the reliability of forecasts for economic development of the CA states, does not attract financial resources for joint investment in major energy facilities, and ultimately, is not conducive to the integration process. Forecasts show significant growth in energy and water demands in the CA countries.

The road map to improving management of hydropower objects is a joint plan for creating conditions in phases in the process of integrating the hydropower sector. It contains three stages and each stage corresponds to a higher level of integration in the joint use and development of hydropower resources from transboundary rivers.

### **Phase 1. Preparing Separate Elements of the Collaborative Mechanism**

Phase 1 includes actions that are aimed at creating a legal and institutional framework for cooperation in the use and development of hydropower resources of the Syr Darya and Amu Darya and includes the following:

1. Development of a coherent regional mechanism of hydropower regulation to use and develop the hydropower potential of the Syr Darya and Amu Darya.
2. Approval and adoption of the Roadmap.
3. Approval of the principles of cooperation in the CA hydropower sector, taking international norms in water law and the specific characteristics of river basins into account.
4. Organising the intertrade of energy resources on a commercial basis with the conclusion of long-term contracts between interested parties and the creation of a commercial operator.
5. Development and approval of joint fuel and energy balances across the CA states that will cover the winter energy shortages that occur in the states in the upper reaches of the river flows.
6. Approval of drawdown schedule for the Naryn – Syr Darya reservoir and the Vakhsh HPP cascade during the growing season with the condition that they work in an irrigation regime.
7. Approval of conditions for the transfer of electricity between CA states.
8. Preparation of financial and investment mechanisms for the joint construction of hydropower plants.
9. Assessment of the impact of hydropower regulation processes on the environment in the Aral Sea basin.

The completion of this phase would lead to the formation of separate elements for the collaborative mechanism and the practical implementation of these.

### **Phase 2. Practical Development of the Elements of Collaboration**

1. Evaluation of the results of the commercial operator in intertrade energy resources and the creation of recommendations for their development.

2. Approval of a legal mechanism for the joint construction of the HPP accounting for the possibility of joint management and defining investment mechanisms of financing.
3. Protection of joint investments by providing a national regime or a more favourable regime depending on which of them is most favourable.
4. Practical implementation of the recommendations prepared based on joint fuel and energy balances among the CA states.
5. Identification and elimination of legal and regulatory impediments for the transition to a parallel operating regime for the power system in the UES CA configuration.
6. Preparation of the draft Agreement on the Interaction of the CA States on the Effective Development of Hydropower Resources in the Syr Darya and Amu Darya Basins.
7. Development of environmental requirements and constraints for the joint management of water resources on the transboundary rivers.
8. Coordination and organisation of a partnership with the regional CA bodies that deal with issues of transboundary water resource management and water security.

### **Phase 3. The Formation of the Collaboration Mechanism**

1. Adopt the Agreement on the Interaction of the CA States on the Effective Development of Hydropower Resources in the Syr Darya and Amu Darya Basins with the establishment of the functions and powers constituted by the joint bodies.
2. Formation of a managing and permanent executive hydropower regulating body in the Amu Darya and Syr Darya basins.
3. Training and development of regulatory, legal, institutional, and economic as a basis for the functioning of regulatory authorities.
4. Enhancing the interaction between national and regional regulatory bodies and commercial operators.
5. Development and approval of national and regional hydropower sector development programs, definition of financial mechanisms for joint investment.
6. Development and approval of programmes to maintain the ecological balance in the Aral Sea basin.

Upon completion of Phase 3 of the Roadmap, the regulatory, legal, economic, and institutional conditions should be in place for the managing and executive bodies to function as the joint management of the hydropower resources of

the Syr Darya and Amu Darya basins. They should also be capable of providing the integrated management of water and energy resources across the CA transboundary rivers.

Strengthening regional cooperation would result in more active participation from the CA countries in international conventions related to transboundary water resources. Unfortunately, though, as is shown in *Table 5.4*, this is still at a low level and does not allow for production based on international standards, guidelines and best practices, or a harmonised approach to solving problems of interstate water use and protection of water quality.

Agreement (convention)	KZ	KG	TJ	TM	UZ
The Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Helsinki, 1992)	•				•
The Convention on the Law of Non-Navigational Uses of International Watercourses (New York, 1997)					•
The Protocol on Water and Health (part of the UNECE Water Convention, London, 1999)					
Protocol on Civil Liability and Compensation for Damage Caused by the Transboundary Effects of Industrial Accidents on Transboundary Waters (to the UNECE Water Convention and the UNECE Convention on Industrial Accidents, Kiev, 2003)					
Convention on Environmental Impact Assessment in a Transboundary Context (Espoo, 1991)	•	•			
Protocol on Strategic Environmental Assessment (to the Convention on Environmental Impact Assessment, Kiev, 2003)					
Convention on the Transboundary Effects of Industrial Accidents (Helsinki, 1992)	•				
Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (Aarhus, 1998)	*	•	•	•	
Protocol on Pollutant Release and Transfer Registers (to the Convention on Public Participation, Kiev, 2003)					
The Convention on Wetlands of International Importance, especially as Waterfowl Habitat (Ramsar, 1971)	*	*	*	*	*
The UN Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa (1994)	*	•	•	*	*
The UN Framework Convention on Climate Change (1992)	*	*	*	*	•
The Kyoto Protocol to the United Nations Framework Convention on Climate Change (1997)	*	•	*	*	*

**Table 5.4**

Participation of Central Asian Countries in Various International Agreements on Transboundary Water Resources

Source: [www.un.org/ru/ga/unesp/](http://www.un.org/ru/ga/unesp/)

Note: • – signed \* – ratified. KZ – Kazakhstan; KG – Kyrgyzstan; TJ – Tajikistan; TM – Turkmenistan; UZ – Uzbekistan

Participation in international agreements should be considered as one of the conditions for improving the legal mechanisms for the transition to integrated water resource management in transboundary river basins. In addition, it is necessary to bear in mind that this would increase the CA countries' opportunities to access information on water resource management and the sustainable use and protection of the resources.

For example, the UN's specialised agencies and other international organisations are in the process of developing global water resource programmes and publishing reports in this field. Water resource organisations under UNESCO include the International Hydrological Program, the UNESCO-IHE Institute for Water Education, the World Water Assessment Program, and other water resource centres. UNESCO supports an information portal on water resources and publishes a number of analytical reports on relevant topics. The UNESCO database of publications includes 119 publications on water resources.

Fresh water resources are a priority area for UNEP activity. Over the past decade, this organisation has prepared more than 70 publications on water resources. Acting under the aegis of the UN Global Environmental Monitoring System (GEMS – Water), it collects and disseminates data on the status of water quality of inland waters on a global scale as well as status trends.

The FAO – Water portal is dedicated to the activities of the Food and Agriculture Organisation (FAO) in the field of water resources. The portal contains numerous publications on this topic.

As part of the Hydrology and Water Resources Program, the World Meteorological Organisation (WMO) carries out various activities that monitor the water cycle.

Publications from the Intergovernmental Panel on Climate Change (IPCC) include information about the observed and forecasted dynamics of water resources, water quality, and aquatic diversity. Currently, the most important publications from the IPCC are the Fourth Assessment Report: Climate Change (AR4, 2007) and the Climate Change and Water Resources technical report (2008).

Since 2006, the World Water Council has prepared about 35 publications on water resources; the Global Water Partnership has released a number of publications on integrated water resources management.

Water resources appear to be a priority area for the World Business Council for Sustainable Development World Business Council for Sustainable Development, which has recently prepared a number of publications on this topic. The report "Facts and Trends: Water" (2009) provides a review of major findings on water resources and issues that the society is facing.

1.	“Global Environmental Outlook” UNEP reports	contains chapters on water resources
2.	UNEP World Water Assessment Program (WWAP)	publishes regular World Water Development Reports (WWDR) (every three years) (since 2003). These reports provide a comprehensive assessment of the world’s freshwater resources
3.	World Health Organisation (WHO) / UN International Children’s Emergency Fund (UNICEF) Joint Monitoring Program for Water Supply and Sanitation	The Program’s reports provide an assessment of progress towards Millennium Development Goals indicators related to drinking water and basic sanitation
4.	Global Annual Assessment of Sanitation and Drinking-Water (GLAAS)	GLAAS is a UN–Water initiative implemented by the WHO. The objective of UN–Water GLAAS is to provide policy makers at all levels with a reliable, easily accessible, comprehensive and global analysis of the evidence to make informed decisions regarding sanitation and drinking-water. Under the Initiative the WHO publishes several reports on water resources and population health, covering particularly issues of access to sanitation and safe drinking water
5.	UNEP International Resource Panel	Water quantification and measurement, efficiency and effectiveness of water resources (2011/2012)
6.	International Decade for Action “Water for Life” 2005–2015	The United Nations General Assembly, in December 2003, proclaimed the years 2005–2015 as the International Decade for Action “Water for Life”. Its primary goal is to promote efforts to fulfill international commitments made on water and water–related issues in the United Nations Millennium Development Goals by 2015. Major themes of the International Decade “Water for Life” include: water scarcity, access to sanitation and health care, gender aspects of water supply, capacity building, financing, cost estimates, integrated water resources management, transboundary water issues, environment and biodiversity, disaster prevention, food and agriculture, pollution and energy. UN Water is coordinating the International Decade for Action “Water for Life”, 2005–2015. UN–Water is the United Nations system–wide inter–agency gathering of all relevant agencies, departments and programs involved with water–related issues

The report “Business in the World of Water: World Business Council for Sustainable Development Water Scenarios to 2025” (2006) deals with the global scenarios in the water sector.

A number of publications on the biodiversity of inland water have been prepared under the Convention on Biological Conservation. The Pacific Institute is one of the leading organisations releasing publications about the global and US water resources. The Institute’s key publication on water resources is a biennial report, “World Water Resources”, which is available online. The Worldwatch Institute publishes its annual “State of the World” report where considerable attention is placed on water resources. The fact

**Table 5.5**

Some global programmes and reports on water resources.

Source: EEA, 2011

lists on the indicators, called Vital Signs, consider the state of water resources. The Institute has also prepared reports on water management issues.

Some other organisations also release water statistics and relevant maps, at a global level.

Programme or organisation	Key areas or content
UN–Water (“Statistics”) and World Water Assessment Program (“Facts and Figures”) websites	Water resources statistics
Environment and Energy Statistics of the UN Statistics Division	Preparation of guidelines, data collection, arrangement of technical cooperation and coordination of activities related to environmental statistics and indicators. In 2010, the 41 <sup>st</sup> session of the UN Statistical Commission approved International Recommendations for Water Statistics
System of Environmental–Economic Accounting for Water Resources (SEEAW)	Comprehensive data on water resources and water management. SEEAW provides necessary conceptual framework for the organisation of physical and economic information related to the support of integrated water resources management. The UN Statistical Commission adopted the SEEAW as an interim statistical standard in 2007, at its 38 <sup>th</sup> session
AQUASTAT database (FAO)	Information on water resources and agriculture, by country
Waterwiki	Supported by several UN agencies, information on water resources, by country
Information resources of the Joint Monitoring Program for Water Supply and Sanitation	Maps, figures and tables to demonstrate progress towards Millennium Development Goals
World Bank	Data and statistics on water resources in relevant section of the WB’s website
UNEP–GEMS under the GTOS/Water Program	GEMStat database provides access to national water quality monitoring data
Global Runoff Data Centre	Access to data on river runoffs
Earthtrends database of the World Resource Institute	Data on the state of water resources and freshwater ecosystems
Database of the International Benchmarking Network for Water and Sanitation Utilities	Information on water consumption and sanitation, as well as on the activities by relevant utilities

**Table 5.6**  
Organisations publishing water statistics resources at the global level

Source: EEA, 2011

As the water quality in transboundary river basins is an important indicator of safe water use, the international organisations recommend, in the global programmes and reports, additional aspects of cooperation that provide for the development of joint assessment criteria and water quality targets and the exchange of relevant information. The achievement of targets in this area calls for international intergovernmental agreements and the availability of mechanisms and bodies for making and implementing decisions.

# Cooperation Priorities for Central Asian Countries in Sharing of Transboundary River Resources

## **6.1. Adjusting Water Resources Management to Climate Change and its Impact on Water Resources in Central Asia**

Climate change is a multi-faceted and interdisciplinary problem, calling for an approach based on sustainable development principles, with an emphasis on changes in global consumption and supply patterns.

The effect of climate change on the population and natural ecosystems is expanding. While it is widely accepted that some climate changes is inevitable, understanding that joint efforts could help prevent many of its negative effects is growing. Efforts must be focussed on key areas, including energy efficiency, transportation, the protection of water resources and biodiversity and renewable energy resources.

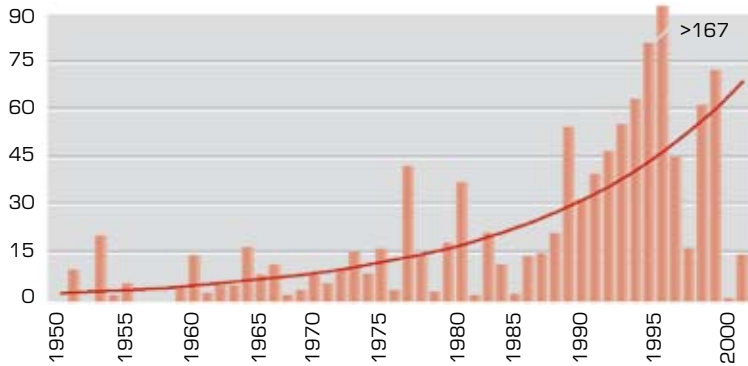
The global community has achieved significant progress in addressing the new global problem that is climate change. Initial research and the resulting joint response measures have received international legal support with the adoption of the UN Framework Convention on Climate Change. It was open for signature at the Earth Summit in Rio de Janeiro on May 9, 1992, with 154 countries including the European Community joining it. On March 21, 1994, the Convention came into force, with 189 countries having acceded to it to date.

The objective of the UN Framework Convention on Climate Change is to reduce anthropogenic emissions of greenhouse gases. The Convention imposes different obligations on its member countries depending on their potential, economic pattern and available resources.

The most recent UN Summit of Sustainable Development (Johannesburg, 2002) recognised the consequences of climate change as one of humanity's global challenges. The economic loss from the adverse consequences of climate change and increased frequency and magnitude of natural disasters is ever growing, having reached an unprecedented level in excess of \$200 billion (see Figure 6.1).

**Figure 6.1**  
Economic costs of  
natural disasters

Source: UNEP,  
2002: 272



Measures to mitigate the consequences of climate change include adaptation to an increase in average temperatures, a seasonal cycle shift, and increased frequency of extreme weather phenomena. The question is not whether it is necessary to adapt to climate change, but how to do it. To analyse the likely long-term scenarios, global models have been built. Although these scenarios have yet to be elaborated in sufficient detail at regional or national levels, they have proven to be instrumental in identifying the key consequences of climate change, forecasting and identifying adaptation priorities.

The UN Framework Convention on Climate Change has laid solid groundwork for concerted international action. However, it was not until the signing of the Kyoto Protocol in 1997, that countries' obligations were defined in terms of clear targets for a definite period of time. The Protocol has not only formulated specific targets, but also proposed innovative mechanisms such as joint implementation projects, clean development mechanism and emissions trading. To some extent, these mechanisms had been applied before the Protocol came into effect. This document is a crucial step towards a global system of response to climate change. It can also promote new technologies, in particular, in the energy and transportation sectors, and can help many countries to transform their economies in line with the requirements of the 21<sup>st</sup> century and to make the transition to sustainable development. In this sense, the Protocol can be seen as a powerful tool of the future. Bearing in mind that the Convention calls for consistent steps towards its ultimate goal, the Protocol stipulates that parties' commitments can be revised from time to time.

Climate change poses a serious potential threat to the environment, with the so-called greenhouse effect being its most immediate impact. The main consequences of climate change include an increase in mean global surface temperatures, changes in precipitation levels, the hydrological regimes of water bodies, and in the quantity and quality of water resources. Compared to

the second half of the 19<sup>th</sup> century, the average global surface temperature has increased by 0.3-0.6°C.

As a result, mountainous regions are likely to lose part of their glaciers, which will result in the lowering of the snow line. This will also affect the surface runoff and water intake for rivers.

The focus on the adaptation and mitigation of climate change issues is continually growing, both nationally and internationally. Climate change caused by human activities and the impact of these pose a threat to the security of individual territories and states and trigger energy, food and environmental crises, and, overall, a humanitarian crisis.

The UN reports that over the last five decades, the frequency and intensity of dust and sandstorms have increased, their geographic coverage has expanded, the damage ratio has grown and the development process has been accelerated.

The most degraded countries in North-East Asia experienced 32 dust and sandstorms in 2001; the most severe dust and sandstorm recorded during recent decades took place in China and Mongolia in early 2002 and caused a historic environmental hazard in the subregion. In addition to North-East Asia, dust and sandstorms have also been occurring in Central Asia, South Asia and Australia. Central Asia is one of the subregions with a high frequency of dust and salt/sandstorms.

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change in 2007 recognised that these changes have significant socio-economic impacts: in the period 2000-2006, the frequency of disaster from extreme events globally increased by 187% compared to the previous decade. Many river systems are being affected by anthropogenic climate changes; in the same period, global economic damage from flooding events and heavy storms was estimated at about \$25 billion.

In Southern Europe, Caucasus and Central Asia, it is projected that climate change will lead to high temperatures and drought and to reduced water availability, hydropower potential, summer tourism and crop productivity.

In Central and Eastern Europe, summer precipitation is projected to decrease, causing higher water stress. Many reservoirs show deviations from the established technological regime caused, to some extent, by impacts of climate change.

The negative impacts of climate change on water resources will affect countries' medium- and long-term economic development and decrease production and food availability.

Many regions demonstrate a clear trend to reduce or increase the volume of runoff, which leads to a serious change in the stability of water consumption in almost all sectors of the economy. For example, the Strategic Projection for the Period of up to 2010-2015 of Climate Change Expected in Russia and its Impact on Sectors of the Russian National Economy (Roshydromet, 2005) indicated that changes in the seasonal river runoff resulting from the current and expected climate change should be taken into account in the hydropower industry. Projected changes in river runoff will affect the inflow of water to large reservoirs. The negative impacts of climate change on areas adjacent to reservoirs include: probable flooding of settlements; expansion of downstream polynya accompanied by deterioration of climate conditions on reservoir banks (higher air humidity, fog frequency, poorer visibility, etc.); more slush icing; likely ice jams downstream from polynya, and cracks and leads on reservoir ice. Forecasted changes in water inflows to reservoirs will require that their operation regime be revised taking into account the interests of key users, primarily, hydropower and environmental protection.

In the agricultural sector, the impact of climate change is felt through the changing rain patterns and the increasing numbers of extreme weather events, generally resulting in further droughts and floods.

Rapid glacier melting, one of the major consequences of climate change, can cause mountainous areas to lose a significant portion of glaciers, thus affecting surface runoff and river flow rates, which will, in turn, cause more frequent and devastating floods. In the future, following the depletion of glaciers and loss of their moisture-accumulating ability, river flow rates will decrease, with the self-purification capacity of rivers and water quality likely to decline. Therefore, adaptation of water management at a regional or basin level to climate change calls for concerted water use policies and considered use of water energy resources.

The high degree of the risk of economic loss from the impact of climate change on water resources calls for urgent adoption of coordinated regional and national measures to adapt interstate water management and develop integrated water management arrangements for transboundary rivers in Central Asia. The impact of climate change on water resources is particularly evident in Central Asia. In this region, the Aral Sea historically played an important role in mitigating cold north winds in autumn and winter as well as the heat in summer. With the desiccation of the Aral Sea, summers have become drier and hotter, and winters have become cold and long. Dust storms have become more severe, particularly on the west coast.

The state of glaciers and snow cover is the main indicator of climate change in Central Asia. For example, the Tien Shan has more than 8,000 glaciers, with an area of 8,169.4 km<sup>2</sup>. Freshwater reserves concentrated in mountain

glaciers are estimated at 650 billion m<sup>3</sup>. In 1960-2005, over 1,000 and 100 glaciers disappeared in the Pamir-Alai and Trans-Ili Alatau respectively. There are several reasons for ongoing glacier degradation, with global warming being the primary cause.

UNEP reported that the recent decades have seen a rise in surface air temperatures by about 0.6°C and by 1.6°C in mountain areas. Natural causes of glacier melting in Central Asia include pollution with dust (up to 20 g/m<sup>2</sup> of dust settles on glaciers every year) carried from dust storms in Iran, Afghanistan, China and other desert regions, and, more recently, the drained area of the Aral Sea.

The anthropogenic cause of glacier degradation is also associated with the desiccation of the Aral Sea and increased wind erosion of the dried-out sea floor; experts estimate annual salt and dust transfer at about 70 million tonnes. The dust cloud was found to include particulate matter containing agricultural pesticides, fertilisers and other harmful components of industrial and domestic sewage. Sand particles are carried by winds in Asian deserts, with some settling on the Tien Shan and Pamir glaciers, accelerating their melting, and the remainder crossing the Pacific and reaching North America, Atlantic Ocean and even Greenland. Ice analysis has shown that particles of Asian origin began to arrive more frequently during the last decade.

A significant increase in the duration of heat exposure (drought) is becoming evident in Central Asia. The consequence of observed climate change is felt through an increase in the number and severity of weather and climate anomalies, with their number having risen by 40% over the past 20 years. Ongoing changes in the region's climate system affect the ecosystem and economic activities, especially in sectors that rely on water and land resources.

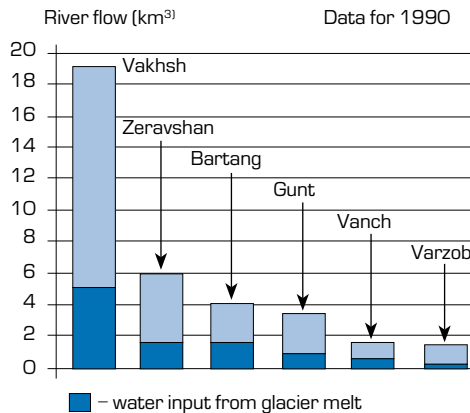
The main watersheds of the Amu Darya and the Syr Darya are located in mountainous areas. The main origin of the water for the majority of rivers comes from melting snow, while lesser volumes are provided from glaciers and rain. Depending on the altitude of the watershed and the quantity and timing of the precipitation, the mix of sources of water supply for rivers can vary significantly, thereby affecting runoff conditions.

The hydrographic curve in the mountain rivers is peculiar in that runoff can fluctuate within a year and even within a single day. Thus, during the cropping 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.

Glaciers in Tajikistan and Kyrgyzstan 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 downstream areas (and countries). 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 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 when it is needed most. However, these ice reserves are unstable. At present, diminishing glaciers are reported all over the world, and whereas the smaller glaciers disappear entirely, the larger ones disintegrate.

Melting water from glaciers in Tajikistan contributes between 10 and 20% of the runoff in large rivers, and in hot and dry years their contribution may rise as high as 70% (see Figure 6.2).

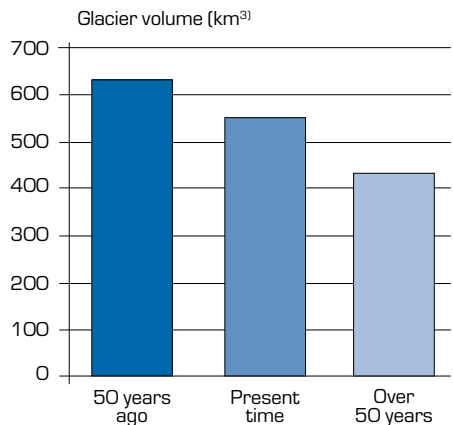


**Figure 6.2**  
River runoff in  
average water year  
and contribution of  
glacier melt

Source: RT, 2008: 41

An assessment of the effect of climate change on the glaciers in the Pamir-Alay shows that since the first data in 1930 when measurements started, the total area of glaciers in Tajikistan has shrunk by about one-third. The decline has been particularly dramatic in the 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 a lesser extent in the 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. Over the past century, glaciers in Tajikistan on the left bank of the Panj river in Afghanistan have decreased 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 and water reserves held by glaciers in Tajikistan may decrease by 15 to 20% and 80 to 100 km<sup>2</sup> respectively, based on the condition they are in today, large glaciers and glacier systems will survive. The glacier-fed runoff of the Panj, 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 (see Figure 6.3).



**Figure 6.3**  
Change in the glacier volume in Tajikistan

Source: RT, 2008: 38

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 surface size of the lakes.

An assessment of changes in the glaciers of the Pskem range in the western Tien Shan has allowed the current pace of deglaciation to be determined. During the past twenty years, glaciers in this area have been shrinking by 16.8%. The estimate of the reaction by glaciers to climate change in the Gissar-Alay mountains in Uzbekistan demonstrates that with a 50% decline in precipitation and a temperature rise of 30°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.

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 in 1957.

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 caused by warming in lowland river basins reducing the depth of permafrost, thereby increasing the losses in runoff due to infiltration and, of similar importance, by the warming reducing the period of snow accumulation in the run-up to the spring floods.

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 21<sup>st</sup> century, runoff is poised to be strongly affected by the melting of glaciers which goes back to the early 18<sup>th</sup> 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 20<sup>th</sup> century and persisted into the first half of the 21<sup>st</sup> 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 Balkhash basins.

At a later stage, as water reserves in glaciers deplete and the draining of water resources in the river basins downstream from 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 final decades of the 21<sup>st</sup> 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 will be accompanied by an increase in the volatility, frequency and intensity of hydrological droughts. 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 water shortages in the longer run.

Water balance models suggest that supplies of water in terms of both quantity and quality are set to deteriorate. Higher temperatures will result in the depletion of surface water resources and droughts. Changes in river and lake runoffs will 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.

Many river basins in Central Asia already experience water scarcity; their climate vulnerability assessment (CSA) must determine the likely level of risk for investment projects and measures to reduce or eliminate them. The identification of sites at risk, evaluation of sources and causes of vulnerability are important to the pre-project design. Unfortunately, there is no universal methodology for this assessment as yet and, therefore, the CSA should be developed for each specific site in a transboundary river basin.

Development of adaptation measures in the Danube River Basin can be cited as an example. The Danube is the second largest river basin in Europe after

the Volga River covering 19 countries. Contracted Parties to the Convention for the Protection of the Danube in 1994 included 13 countries (Austria, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Moldova, Romania, Slovakia, Slovenia, Serbia and Ukraine) and the European Union. The member countries of the said Convention committed themselves to cooperating on fundamental water management issues and taking all appropriate legislative, administrative and technical measures to maintain and improve the quality of the Danube River and its environment. The Conference on the Adaptation of Water Management to the Effects of Climate Change in the Danube Basin held in 2007 in Vienna discussed a variety of strategic adaptation measures to maintain the sustainability of the water basin. They include such steps as evaluation of the current situation, the development of adaptation strategies for water management, the drafting of new flood protection measures that took climate change into account, and the identification of further actions to improve regional climate change scenarios and its impact on the water use pattern.

The peculiarities of transboundary water resources due to the natural, geographic and economic conditions of the river countries' competing national interests pose specific management challenges. In this context, adaptation calls for an integrated approach based on the basin principle of river water use taking into account the specifics of the development of each country and the nature of economic integration in the basin. Effective and long-term achievement of the goals of the majority of adaptation measures in the transboundary river basin, naturally, calls for interstate coordination and cooperation.

Political, legislative and institutional frameworks at the national and regional levels should all support adaptation to climate change. This should also be carried out at a basin level, which will require more effective international cooperation and respective coordination mechanisms.

To monitor the water management situation and support the modelling of the water vulnerability scenario due to climate change and the underlying water policy priorities, strategies and plans for the development and operation of water facilities, it is necessary to meet information needs of the parties involved. Water resource information must support the understanding of the need for cooperation between river basin countries and water users (agriculture, industry, hydropower, etc.).

The impact of climate change on water resources depends not only on changes in the volume, timing and quality of runoff, but also on the properties of the water management system and the factors that impact it (technical condition of the water system, timeliness and sufficiency of funds for repairs and reconstruction, the development of water- and energy-saving technologies, improvements to the system management, staffing, scientific

and technical support, and so on). Comprehensive (integrated) water resources management should strengthen water users' adaptation and mitigation capacity.

It is recognised that climate change affects the water resources situation in Central Asia. Hydropower and agriculture in this region are particularly sensitive to climate change as it has a direct impact on the river flow and, as a result, the conditions of development for hydropower and agricultural production.

The mitigation of negative consequences of climate change on the region or a specific sector depends on the regional- and national-level readiness to counteract and mitigate potential economic loss. In this regard, investment projects must include a special section that evaluates the impact of the climate change, with adaptation measures to reduce or eliminate investment risks, i.e. a climate assessment of the project's vulnerability should be performed.

Given the high vulnerability of water resources to climate change and associated risks of declining levels of food, energy and environmental security, and the growing water demand for these purposes, international financial development institutions should be more actively involved in adaptation measures.

Comprehensive assessment of the costs of adaptation measures and risk reduction requires more research into the prediction and monitoring of climate change, considering these as a crucial pre-investment stage for projects related to water use in different industries.

Water shortages are considered to represent the main impediment to the development of Central Asian countries both in the present-day conditions and for the future. The expected increase in water consumption is bound to stiffen competition for water at both regional and national levels between irrigation, hydropower generation and other sectors of the Central Asian economy. All over the world, increasingly close attention is being paid to the problems associated with the exposure of the economy and the population to climate change. Various scenarios regarding the consequences of climate change are being developed and scrutinised, and various methods are being proposed to address 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. Estimates 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.

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

The states in the Aral Sea basin all face the task of ensuring more effective and economical use of water, management of the demand for water, and finding a compromise between the interests of the upstream and downstream states.

The joint development of adaptation measures and finding a compromise between environmental demands, hydropower and irrigated farming of the region's countries are important objectives for the overall Central Asian water management strategy in the context of climate change.

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-conservation technology, particularly in the irrigation of farmland, as well as the expansion of international cooperation in the use of hydropower resources at 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 the current and pending climate 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.

The Intergovernmental Panel on Climate Change (set up under the auspices of the UN) published the report "Climate Change 2007". This paper provides a review of the research, technical and socioeconomic data needed to comprehend the climate change process and its potential effect, as well as the methods of adaptation and of mitigating its negative consequences. The report includes a comprehensive summary of all currently available data on climate change.

Where various countries use water resources jointly, all interested parties should develop coordinated initiatives and mobilise their financial resources. The above-mentioned report 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 advanced technology by providing transparent, predictable and stable incentives;

- political initiatives should be multi-layered, with governments deploying a wide variety of political instruments including standard requirements, taxes, duties, trade permits, voluntary agreements, subsidies, financial compensations, research and development programmes and information. The optimal approach for political initiatives may vary depending on the 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. Barriers include market prices that bear 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 the 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, UNECE water resource experts prepared a draft manual on the adaptation of water resource management to climate change in the UNECE 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 that needs to be adapted to conditions at 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 the water levels in basins; and
- the assessment of climate change sensitivity at 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 conceptual 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, dam safety, land use planning etc.;
- preparation for extreme weather conditions by enhancing awareness, equitable distribution of water resources and joint management;
- response to extreme weather conditions, including evacuation, medical emergency assistance, the distribution of safe drinking water, management of hazardous substances, institutional development, personnel training and the divulging of information; and
- preparation for rehabilitation, reconstruction, legal measures, and the collecting and circulation of information in the event of an emergency.

The Ministerial Declaration adopted by the 5<sup>th</sup> 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.

## **6.2. Dam Safety on the Transboundary Rivers in Central Asia**

Dams are the most important structures in the water and hydropower systems and are subject to rigid requirements governing their protection from internal and external threats, prevention or mitigation of adverse effects of malfunctions, failures, accidents and emergencies on the operating personnel, the population and the environment. Dams, dykes, sluices and dam outlets form the so-called water front, keeping a large mass of water in the basins of water reservoirs, ponds and settlement ponds. The height of the water level determines the water mass energy and the pressure on the load-bearing elements of a dam. A failure in the waterworks causes a surge of water in the tailwater, quickly eroding the dam body. Water spreads along the channel and adjacent areas at a high speed, forming large flooding areas, with the entailing impact differing from the impact of natural flood waves. When passing, a dam failure surge destroys almost anything in its path, including downstream waterworks.

Dam failure is defined by the International Commission on Large Dams (ICOLD) as the “collapse or movement of part of a dam or its foundation, so that the dam cannot retain water.” A failure results in the release of large quantities

of water, posing serious risks for the population or property downstream. Ensuring safety and reliability is a mandatory requirement for the construction of dams, which are hydrodynamically dangerous objects. The large number of dams makes their safe operation socially, economically and ecologically important. A dam failure can entail extremely negative consequences for the economy and the environment, and its damage can exceed construction costs. Accumulated information provides many cases of dam failures. It should be taken into account that the probability of a dam failure increases steadily with its age, particularly after 30-40 years of operation. The findings of a recent global compilation by ICOLD of information on the failure of dams are as follows:

- the failure rate of large dams has been falling over the last four decades. Of dams built before 1950, 2.2% failed, while the failure rate of dams built since 1951 is less than 0.5%. The proportion of dams failing varies little with the height of the dam; most failures involve small dams and newly built dams. Some 70% of failures occur in the first ten years of life of the dam and proportionately more during the first year after commissioning;
- foundation problems are the most common cause of failure in concrete dams, with internal erosion and the insufficient strength of the foundation each accounting for 21% of failures;
- the most common cause of failure of earth and rockfill dams is overtopping (31% as primary cause and 18% as secondary cause). This is followed by internal erosion in the body of the dam (15% as primary cause and 13% as secondary cause) and in the foundation (12% as primary cause and 5% as secondary cause);
- with masonry dams, the most common cause is overtopping (43%) followed by internal erosion in the foundation (29%);
- where other waterworks were the seat of the failure, the most common cause was inadequate spillway capacity (22% as primary cause and 30% as secondary cause); and
- the post-failure action most frequently reported was that the scheme was abandoned (36%), the construction of a newly designed dam (19%) and overall reconstruction with the same design (16%).

Thus, the main causes of dam failures are overtopping and inadequate spillway capacity. In this context, accuracy of estimates and forecasts of hydrological regimes and their cycles, reliability of source data for calculating dam parameters taking into account global climate change is a particularly urgent matter. Dam safety is affected by the amount and frequency of extreme precipitation, whose changes are hard to predict. However, global

climate change is expected to cause more frequent extreme precipitation and, as a result, changes in river flow characteristics. This issue introduces new dam safety criteria, and these relate in particular to the legal status of the entity owning and operating the structure, the selection of cost-effective parameters for dam spillovers and reservoirs that are then to be operated safely under the extreme conditions of frequent or prolonged floods. In turn, this brings an economic aspect to bear, as it makes the construction and operation of waterworks more expensive.

	Number of large dams	Total reservoir water storage capacity (million m <sup>3</sup> )	Total installed capacity of HPP* (thousand kW)
Kazakhstan	12	89,842.6	2,260
Kyrgyzstan	20	21,928.1	2,950
Tajikistan	9	32,519.5	4,707
Turkmenistan	15	3,214.2	0.001
Uzbekistan	54	20,840.95	1,739
TOTAL	110	168,345.35	11,657

**Table 6.1**  
Summary of main indicators of large hydraulic projects in Central Asia

Source: UNECE, 2007: 66.

Note: \*Data provided as of 01.01.2010

The existing water management infrastructure in Central Asia was built during the USSR times. The design, construction and operation of dams, reservoirs, canals and other water works (WW) followed the unified technical regulations. These regulations provided for routine monitoring, maintenance of structures, capital repairs, and if necessary, reconstruction. Deductions based on levels of annual depreciation were used to finance capital repairs, and this mechanism operated quite efficiently. Prior to 1991, once every five years a comprehensive inspection of large water control structures was carried out by sectoral commissions, often with the participation of specialised design, assembly, construction and scientific research organisations. The commission made an appraisal of the structure's condition and issued recommendations and a description of the activities needed to improve safety levels. After the collapse of the Soviet Union, these operations were fully discontinued. The all-USSR organisations and institutions responsible for field observations and safety assessments of large facilities were either dissolved or shut down, and not all Central Asian countries managed to establish specialised design and research entities. Thus, the overall monitoring of the condition of dams and other waterworks decreased; preventive maintenance and repair work in Central Asian countries was not performed in a timely manner. Sufficient funds were not allocated to the observation and replacement of instrumentation that had become disabled during operation; no specialised entities are in place. Due to the lack of funds, preventive as well as repair and rehabilitation work on a range of dams, mostly for irrigation purposes, has not been carried out to the extent needed. As a result of these and other factors, the technical condition of

many dams has deteriorated and started to pose a danger for their operation, especially during the period of flood discharge. Central Asian countries have been raising foreign investments (World Bank, Asian Development Bank and others) to keep large dams and other large waterworks in a safe condition. However, these funds are not sufficient and significant effort and increased funding is needed to improve the safety of the existing water management infrastructure in Central Asia.

In the Central Asian countries, the legal frameworks in the area of dam and other waterworks safety exhibit significant differences, and demonstrate different approaches. Uzbekistan has adopted a special Law on the Safety of Waterworks. In the other four countries in the region, separate regulations related to dam safety are included in general legislation on water management, energy and emergency situations.

In 2008, the Interparliamentary Assembly of the EurAsEC member countries adopted a Model Law on the Safety of Waterworks, which will promote the harmonisation of national legislation on dam safety, which will positively impact cooperation in this sector in Central Asia. Uzbekistan has a state body responsible for the supervision of dam safety and the safety of other waterworks (Gosvodkhoznadzor). It controls and supervises the technical condition and operational safety of dams and related facilities. It also oversees the safe condition of the bank-protecting and riverbed-regulating structures that are under the jurisdiction of local authorities. In Kazakhstan, Kyrgyzstan and Tajikistan, public supervision bodies under the respective Ministries of Emergencies have control over dam safety as one of their functions. In these countries, water resources and energy authorities also exercise control over the dam safety within their statutory power. In Turkmenistan, responsibility for safe operation of waterworks including dams and reservoirs is vested in the Ministry of Water Resources. The notification of accidents is initiated by WW operating organisations in accordance with rules of operations for these structures. These organisations then interact with the national emergency services, which in turn take the required measures. In the majority of Central Asian countries, financing of activities concerning dam and other large WW safety is mostly allocated from State budgets. Overall, state allocations towards dam and other WW safety are insufficient. Therefore, to supplement budget funds, loans and grants from donors and international organisations are utilised. All the Central Asian States are members of the CIS Agreement on Interaction in the Field of Prevention of and Response to Natural and Technological Emergencies of January 22, 1993. A framework agreement "On Mutual Aid in Case of Accidents or Other Emergencies at Energy Units in the CIS Member Countries" of May 30, 2002 also sets out the general terms of the countries' cooperation in the event of emergency situations related to dam safety. Issues concerning cooperation in the field of

information provision have been specified by the Agreement between the Governments of the CIS Member Countries on Information Exchange on Natural and Technological Emergencies, and on Information Interaction in the Liquidation of Consequences and Assistance to Affected Population of September 18, 2003. In 2005 in Moscow, the Central Asian countries, with the exception of Turkmenistan, also signed the Agreement between the Governments of the Shanghai Cooperation Organisation member countries On Cooperation when Rendering Assistance in Response to Emergency Situations. Regulations related to cooperation in emergency situations are found in other international documents, in particular the Agreement between the Governments of Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan on the Use of Water and Energy Resources in the Syr Darya Basin of March 17, 1998 and in the Amendment Protocol to the Agreement of May 19, 1999.

Kazakhstan has a total of about 650 major waterworks of various institutional affiliations and types of ownership. According to the Ministry of Emergencies (ME), about 40% of major WW are in urgent need of repair. At the same time, the average rate of depreciation of water management structures is estimated at more than 60%, which has resulted in declining reliability and safety of their operation. A serious problem relates to small-scale WWs, some of which are abandoned and neither have an owner nor serve any function. The poor technical condition of many WW calls for urgent action on the part of government authorities and WW owners to improve their safety. The damage caused by adverse water impacts, e.g. floods, waterlogging, due to unsatisfactory performance of water regulating and protecting structures, is estimated at \$ 50-60 million or more annually.

Specialised legislation on the regulation of HS safety, including dam safety, is lacking in Kazakhstan. The Reservoir Operating Rules, which are departmental guidelines approved by the Water Resources Committee of the Ministry of Agriculture, constitute the legal framework for state regulation in the field of dam safety. Waterworks including dams may be state- or privately owned. Waterworks of strategic importance are state-owned and cannot be leased or transferred to asset management or privatised. The owners of water facilities are responsible for their safe technical condition and for the prevention of technical accidents. Authorised bodies in the area of use and protection of water resources, emergencies and industrial safety should make sure that the owners ensure the safety of their water facilities.

In **Kyrgyzstan**, the basic waterworks infrastructure includes a cascade of six large waterworks, including large dams and hydropower plants. The water resources system includes 103 dams, with 14 of these being large. Over 50 dams are intended to stop mudflows, with a total mudflow retaining

storage capacity of 4.8 million m<sup>3</sup>. These are run by the Ministry of Emergencies.

The major barriers to safe waterworks operation include filtration at dams downstream, depreciation of hydro- and electric equipment, destruction of concrete structures, and the lack of reliable communication means. At many dams, the instruments used to monitor the condition of their structural elements, such as spillways and supporting structures, are in need of urgent repair. The main law governing dam safety issues in Kyrgyzstan is the Water Code adopted in 2005, which contains regulations on emergencies and dam safety. Dam owners and users are responsible for the safety of dams, their safe operation and maintenance, as well as for damage resulting from their improper operation. Permanent and day-to-day control is performed by the owners, and Gosgortekhnadzor is also involved. The technical condition of irrigation dams is monitored by the technical units of the Irrigatsiya State Enterprise, which falls under the Ministry of Natural Resources of Kyrgyzstan. In addition, according to Article 77 of the Water Code, a Commission on Dam Safety is to be established to deal directly with the regulation of dam safety as an independent technical body.

In **Tajikistan**, nine large multipurpose hydraulic projects are operational.

The irrigation infrastructure includes 3,206 headwater intakes on main canals, 219 large facilities at interfarm collectors, major and interfarm irrigation canals. The length of irrigation tunnels totals 26.6 km with a total water intake of 170 m<sup>3</sup>/s; riverbank protection dykes and mudflow discharge routes total more than 2,000 km. As a whole, the depreciation rate exceeds 50% for irrigation and drainage systems and 65% for pumping stations.

In Tajikistan, there is no special law on dam and other WW safety. Legal provisions related to this area are found in different regulatory acts including those in the Water Code. The Ministry of Land Reclamation and Water Resources (Minvodkhoz), the Ministry of Energy and Industry and the Division for State Supervision over Safety of Work in the Industry and Mining under the Government of the Republic of Tajikistan (Gosgortekhnadzor) are responsible for safe operation of dams and other waterworks.

In **Turkmenistan**, the main element of the water management infrastructure is the Karakum Canal, which takes water from the Amu Darya and runs for 1,100 km. Four dam reservoirs with a total storage capacity of 2.5 km<sup>3</sup> have been constructed on the Karakum river, and a second phase of the Zeyid Reservoir for multiyear water flow regulation, with a design storage capacity of 3.2 km<sup>3</sup>, is under construction. Oguzkhan waterworks in the Karakum River (dam is 15 m high, the reservoir has a storage capacity of 700 million m<sup>3</sup>).

To date, 16 large reservoirs are operational, with another 6 dam reservoirs to be constructed and a number of structures in the Karakum river that were erected over 30 years ago are to be reconstructed.

WW safety in Turkmenistan is regulated by technical regulations adopted during the Soviet period. Minvodkhoz and its subordinate territorial subdivisions operating WW and reservoirs are responsible for the safe operation of all waterworks.

**Uzbekistan** has the most developed water management infrastructure in the region. In Uzbekistan, there are 273 major and particularly important WW, including 54 large dams with a total water storage capacity of about 20 km<sup>3</sup>, 35 pumping stations with total productivity of about 3,000 m<sup>3</sup>/s, 29 HPPs, 60 main canals, 64 hydraulic projects, 24 main collectors collecting drainage waters, and bank-protecting and regulating structures with a total length of more than 2,300 km. Significant emphasis is being placed on the further development of the water management infrastructure. Thus, in 2005–2006, the Andijan and Tashkent Reservoirs were equipped with new automation facilities, communication and early warning systems. Pachamar waterworks dam on the Guzadarya river (the dam is 71 m high; the reservoir has a storage capacity of 260 million m<sup>3</sup>).

Uzbekistan is the only Central Asian country where dam safety issues are governed by a special Law on the Safety of Waterworks. State supervision of WW safety has been assigned to the State Inspectorate for the Control of and Supervision over the Technical Condition and Operational Safety of Large and Particularly Important Water Facilities (Gosvodkhoznadzor). Gosvodkhoznadzor also oversees safety of the condition of bank-protecting and riverbed-regulating structures that fall under the jurisdiction of local authorities. In order to carry out field observations and assess the technical condition of dams and other WW, a Diagnostic Centre was established with a Panel of Experts.

Based on a system of monitoring and evaluation of the technical condition of dams and other WW, Gosvodkhoznadzor has set up and regularly updates an information database that is available to government stakeholders.

For Central Asian countries, water sector privatisation poses a political, economic and social challenge. This has to do with the fact that the economic conditions for the creation of the private segment in the water sector are lacking. Due to the lack of its own funds the private sector cannot finance investments in water management infrastructure, which is the basis for development of the water sector. Technological achievements in the water sector designed to contribute to the water problem solution do not solve the problem. Compared to other sectors, the water sector infrastructure is capital-intensive and barely susceptible to technological advances.

The introduction of technological advances to the sector will only reduce investments in water infrastructure sectors between 2015 and 2025 by 6.7%. In the U.S., a large amount ranging from \$71.7 to \$98 billion per year needs to be invested into the water supply and sanitation infrastructure until 2019. This might explain why privatisation accounts for only a small portion of the water sector in the U.S. Given the crucial role played by water, the privatisation of the water sector in Europe and North America has become the subject of national debate involving all government authorities, academia, business community and the public. The shaping of the water sector service market is an objective process, but it calls for careful consideration of all the challenges and a comprehensive study of the particulars of privatisation in other countries before the development of a framework for effective public policies in this area, given the national importance of the issue, the need to consider different opinions and approaches and achieve the best possible neutrality of research. The social consequences of transfer of drinking water facilities and irrigation sources have not been studied to the same extent as the environmental challenges this poses. As a rule, the transfer of water bodies to the private sector is accompanied by higher tariffs and worsening quality of water. Changes may need to be made to the national water legislation of Central Asian countries that will then provide for the privatisation of water resources. Changes in water and other related legal acts should reinforce the legislative requirements on the owner of a water body regarding the safe operation of facilities, fully funding maintenance and repair, and the unconditional fulfilment of all requirements from government agencies responsible for emergencies, sanitation, water resources, environmental protection and anti-competitive behaviour.

The urgency of the privatisation of the water sector is confirmed by an accident at Kyzylagash Reservoir dam (Almaty Province), an incident unprecedented for Kazakhstan, which occurred on the night of March 12, 2010 and resulted in numerous human casualties and enormous economic damages. The dam reservoir, which had a capacity of 40 million m<sup>3</sup>, was destroyed in 2-3 hours by overtopping due to heavy rainfall. However, the main cause of this disaster and the failure of the retaining structure of the reservoir, which had been transferred to a private person for use, was the extremely poor maintenance of the structure, a gross breach of reservoir operation rules by the owner, and a lack of investment in waterworks maintenance activities. The reservoir owner was not interested in investing the proceeds from sale of water to farms and farmers into the safe maintenance of the reservoir, its facilities and equipment. Government authorities did not monitor the reservoir owner's compliance with the operation rules, its filling and drawdown regime during the flood period, receipt of funds and their spending in accordance with intended use, compliance with the repair schedule and equipment with notification

means in case of an emergency on the water body and so on. All these issues call for thorough research based on Kazakhstan's experience of this incident and international best practice in order to develop a legal framework for the safe operation of privately owned waterworks and facilities. In this context, there is another methodological issue to be considered: reservoirs with what capacity and which waterworks can be privately used on terms meeting the requirements for the safety and accessibility of private water services.

Analysis of the disastrous failures of a number of dams, their consequences, causes and patterns of various risks suggests that waterworks (dam) and reservoir safety measures are not always comprehensive. The most frequent causes of accidents include breach of design, construction and operation rules, the low efficiency of state supervision and a lack of funding for waterworks safety measures. Studies have shown that maintenance costs increase significantly after 25-35 years due to the increasing needs for repair. Technical dam management tasks did not take into account the need for significant changes in operation methods depending on the service life of waterworks. No ongoing evaluation and adjustment of operational solutions was performed at the dams that experienced accidents and damages in the context of the ever-changing physical and technical parameters of the structures. Serious mistakes were committed as early as at the exploration stage; the geological conditions and characteristics of river flows, especially during floods, were ignored. This work was often performed by inadequately qualified organisations. Both researchers and designers did not pay enough attention to systematic reservoir operation activities.

Central Asia also has a large number of reservoirs and ponds intended for the collection and disposal of industrial and municipal effluents, which require safe and reliable operation. Kyrgyzstan, for example, has 60 uranium tailing dumps containing \$145 million tonnes of hazardous waste. There is a large uranium tailing dump in the area adjacent to the town of Kara-Balta, which does not have an adequate system of engineering structures resulting in the high probability of dam failures during disastrous mudflows and heavy rainfall. Moreover, the poor state of the tailings dump has caused the contamination of surface and underground waters, which are sources of drinking water supply. A similar dangerous situation exists in the town of Mailuu-Suu in Jalalabad Oblast, Mailuu-Suu river delta, which accommodates 23 and 13 tailings dumps, exposing the population of the Fergana Valley to hazards. A disaster and penetration of radionuclides and other hazardous substances in the Syr Darya will affect 24,000 people in Kyrgyzstan, 2.5 million people in Uzbekistan and 700,000 people in Tajikistan. The Kaji-Sai tailings dump in Chui Province, which has accumulated over 600,000 m<sup>3</sup> of radioactive mass and is in a poor condition, poses a serious risk and direct threat to the nearby Lake Issyk-Kul.

Radionuclides and other toxic ingredients are carried by river basins and channels and associated irrigation and drainage systems of interstate significance and connected with Naryn, Syr Darya and Chu rivers. Moreover, all Kyrgyz uranium waste dumps are located in earthquake and mudflow prone areas. Their destruction threatens not only Kyrgyzstan, but also the states located in these river basins. Therefore, the safety of tailings dumps engineering structures, which include dams and dykes, is a regional challenge and calls for concerted action on the part of all Central Asian states and the international community.

Tajikistan also has a number of uranium tailings sites, whose technical state poses a risk to all those living in the region. These sites are located in the valleys of the Syr Darya basin. Furthermore, the territory of Kyrgyzstan is characterised by high seismicity, which predetermines specific requirements for the safety of dams and reservoirs and ongoing monitoring of the state of natural lakes, many of which are a result of tectonic processes and earthquakes – one of them being Lake Sarez.

The strength of this natural dam that contains a huge mass of water at such a height causes justifiable concerns given the nature of the origin of the dam. Apart from dangerous seismic events, the dam could be destroyed by the erosion of Lake Sarez itself. Cracks, craters and collapses caused by natural shrinkage, weak seismic vibrations and temperatures continuously emerge in the body of the dam. Active deformation of the dam was recorded during the first 10-15 years, with the dam subsiding by 65.4 m between 1913 and 1926. The descent of potentially unstable lake banks, with a rock landslide of more than 1 billion km<sup>3</sup>, would cause a disturbance wave of 150-200 m, the dam failure and the outpouring of Lake Sarez. It is estimated that when this passes along the valleys of Bartang, Panj and Amu Darya rivers, a catastrophic mudflow will affect an area of 52 km<sup>2</sup> across the territory of Tajikistan, Uzbekistan, Turkmenistan and Afghanistan and a population of 5 million people. Given the consequences of the dam failure and a need for huge financial resources for preventive measures, solution of the Lake Sarez problem should be considered in the context of the security of the entire region and it calls for coordinated action by the neighbouring countries and the international community.

In recent decades, a large number of studies and large-scale regional projects have been performed in Central Asia, with recommendations being made for the improved management of water resources and environment in the Syr Darya and Amu Darya basin. For example, research laid the groundwork for the large-scale integrated project 'Syr Darya Control and the Northern Aral Sea' that was implemented by Kazakhstan. The project is of regional significance and not only promotes the improvement of the environment in this part of the basin, but also ensures safe water use

and the reliable operation of many waterworks. However, all these studies and projects pay little attention to the overall security of the entire cascade of dams and reservoirs, especially in the upper and middle reaches of the Syr Darya. Therefore, while expanding cooperation in the water management area, Central Asian countries should identify priorities for joint action to ensure dam safety.

The Cooperation Strategy to Promote the Rational and Efficient Use of Water and Energy Resources of Central Asia (2003) designed to assist the countries of the region in strengthening cooperation in the water and energy sector was developed within the framework of the UN Special Program for the Economies of Central Asia (SPECA). To further this strategy, the project ‘Dam Safety in Central Asia: Capacity Building and Regional Cooperation’ was initiated. The project was supported by the UN Economic and Social Commission for Asia and the Pacific (UNESCAP), and by the UN Economic Commission for Europe (UNECE).

Based on the assessment of the current state of dam safety in Kazakhstan, the report discusses the urgent problems surrounding dam safety and cooperation in Central Asia in transboundary river basins. The convergence of views on the legal aspects of dam safety in transboundary waters calls for cooperation, which should be based on the international legal regulations in this field and experience in bilateral and multilateral cooperation. To resolve the multiple regional conflicts in the operation of transboundary river reservoirs and ensure dam safety, integrated measures should be taken in line with the Strategy to Promote the Rational and Efficient Use of Water and Energy Resources of Central Asia prepared under the SPECA.

Ensuring the safety of waterworks appears to be a systematic process consisting of a number of related procedures aimed at the prevention or containment of accidents and the elimination of the consequences of these. Measures to prevent accidents at waterworks should be viewed as a set of related and interdependent stages including the design, construction, operation and efficient management of these facilities. Given the international experience in ensuring the safety of waterworks, priorities should be defined based on the need to strengthen cooperation in this field. The interests of the region’s countries make the creation of an interstate system for management of the safety of river waterworks necessary, which should be based on common approaches in legislative, institutional and technological domains. The report suggests ways to ensure, at an international level, the safety of waterworks and the prevention of accidents at these facilities.

International experience in the design, construction and operation of waterworks shows that this danger can be eliminated or significantly mitigated to a safe level by ensuring the effective operation of an accident prevention system. Building an effective state system of dam safety is one

of prerequisites for the prevention of accidents. The majority of waterworks are unique, which makes their operation more difficult and each situation specific. These facilities call for systematic efforts to improve their technical condition and safety. However, at present, many of the Central Asian countries have yet to set up a state waterworks safety system, which not only makes these efforts less effective, but also does not allow the development of strategic areas of cooperation in this field. Not all countries in the region have a legislative framework in place to ensure the safety of waterworks or a unified state system for emergency prevention and response customised to waterworks. The regulatory framework for safety of dams and other waterworks is either obsolete or formally isolated from industrial production and construction. The state registry of waterworks is not maintained in a proper manner; international experience in the operation of various waterworks based on the use of advanced monitoring and diagnostics tools has not been analysed. The concept of state policy in this area has not been developed and the functions of government overseeing waterworks safety have not been clearly defined. In this context, the solution of security problems is down to the waterworks operators themselves, which drastically increases the likelihood of emergencies at waterworks. And as the waterworks owners lack sufficient funds, the safe operation of waterworks is not certain.

It should be emphasised that the safety of waterworks in Central Asia has a transboundary context, where states sharing a watercourse should commit to the prevention of the impacts of waterworks accidents on the natural and social environment of the neighbouring states. Therefore, Central Asian countries need to identify priorities for joint actions to ensure dam safety as they expand areas of cooperation in the water sector.

Ensuring the safety of waterworks includes the design, construction and operation stages phases, which means that this is a comprehensive process. Addressing waterworks security problems calls for expertise and responsibility, clear-cut monitoring arrangements and the prompt resolution of emergency liquidation issues. To this end, there is a need to set up a specialised regional scientific and engineering centre, which would provide scientific, technical and institutional support in ensuring the safety of the various types of waterworks, assessing their technical condition, disseminating international experience and developing regulatory documents. For example, the UK has a special government-selected Engineering Corps comprised of technical supervision experts and water engineering specialists. It is recommended that a centre be set up on the basis of scientific and design entities experienced in the development and implementation of security systems for various types of waterworks.

A safety management system for waterworks in transboundary river basins should cater for different levels of interaction.

National and basin-level waterworks safety tasks should include:

- the preparation of proposals for interstate and national programmes to ensure the safety of waterworks safety;
- control over the progress of these programmes and the improvement of sector regulations;
- the creation of sector databases and the maintenance of a waterworks register;
- the coordination and supervision of waterworks security systems; and
- assessments of waterworks security systems and the development of improvement measures.

Design is an essential process laying the groundwork for the future safety of waterworks. Compliance with building codes and regulations is key to the security of design solutions. To achieve this goal, design organisations must have an effective quality assurance system for projects based on international standards (e.g. ISO 9001-2000). Construction entities should also be required to have a quality management system for their construction and installation activities and should also secure smooth operation of the waterworks security system during construction in line with the project. The operator should receive the facility with a security system in place and be able to adapt it to operating conditions. Advanced waterworks security systems should use computer-aided tools for the observation and diagnosis of the state of facilities.

The development and implementation of basin and regional waterworks safety programmes, improvements to the state supervision system, inventory-taking and monitoring of the state of waterworks should be considered as essential framework for the planning of waterworks safety measures.

Interstate-level objectives to prevent accidents at transboundary waterworks should include:

- outlining the vision of the problem by the region's countries;
- cross-border waterworks safety policy-making and the identification of policy mechanisms;
- the development and approval of interstate target programmes, and strategic long- and short-term plans;
- legislative, regulatory, logistical and financial support for the objectives within the framework of these programmes, plans, etc.;

- control over and coordination of the progress of the waterworks security policies, programmes and plans;
- interstate supervision of transboundary waterworks safety measures;
- the licensing of entities responsible for the safety of transboundary waterworks, approval of declarations of security; and
- the state registration of interstate facilities.

Supervision of waterworks is a quite specific area of intergovernmental and interagency activities involving a large number of regulatory bodies and services, ministries, national companies, local authorities and other owners of water facilities. Their interaction is a rather difficult and requires a system of laws and appropriate legal and institutional support. Integration of the information space of the monitoring authorities operating at reservoirs and waterworks in the region is crucial to improving the safe operation of cross-border water facilities. The interests of the region's countries necessitate the establishment of an interstate management system for river waterworks safety, and this should be based on common approaches in legal and institutional spheres.

The measures to prevent accidents at waterworks should be viewed as a set of related and interdependent stages including design, construction, operation and the efficient management of these facilities. There is a need to create an interstate (for river facilities), national, basin and site level of management for the safety of dams and other waterworks. Given the international experience in ensuring the safety of waterworks, priorities should be defined based on the need to strengthen cooperation in this field. Ensuring the safety of waterworks appears to be a systematic process consisting of a number of related procedures aimed at the prevention or containment of accidents and the elimination of the consequences of these.

In this context, it appears to be necessary to develop and adopt an intergovernmental waterworks safety agreement that will make it possible to set up a unified management system in this area and to establish a special regional authority with a regulatory and supervisory role, which will also provide legislative, regulatory and institutional support for the system. Its main tasks will be:

- regional safety policy-making and planning improvements to the interstate waterworks safety system;
- the determination of state inspection procedures;
- the monitoring of progress of respective state policies and major events at a state level;

- control over the operation of waterworks; and
- analysis of all levels of the dam safety management system, with corrective actions for its improvement to be developed and their performance to be monitored.

Ensuring dam safety in Central Asia is a regional cooperation priority, which should be based on international law and the experience of bilateral and multilateral cooperation in this area.

### **6.3. Water-Related Disaster Mitigation**

Losses from water-related natural disasters (floods, droughts, earthquakes and mudflows) are a serious barrier to the achievement of sustainable development goals both for an individual country or region and for the global community as a whole. These disasters are primarily of transboundary nature, with their impact spreading to other states. Globally, there is a lack of effective methods of preparation for these disasters and the mitigation of their consequences, and as a result, the mitigation of the risk has not yet become an integral part of water management. The trend towards the escalation of natural disasters causes disproportionately severe damage to low-income countries. They try to adapt to the consequences of these disasters, but fail to change national and regional-level approaches.

In the future, climate change is likely to cause a rise in the number of dangerous weather phenomena and reduced water availability due to drought or floods, growing competition for water and international conflicts. These phenomena have also become an obstacle to energy security and sustainable development; therefore, there is a need to strengthen international cooperation in mitigating the threat of disaster.

In this context, in 1989 the UN General Assembly adopted Resolution 44/236 proclaiming 1990-2000 to be the International Decade for Natural Disaster Reduction (IDNDR). This effort helped raise awareness of the need for disaster reduction action. Japan has made a great contribution to the achievement of its objectives.

Throughout its history, Japan has faced geological disasters such as earthquakes and their consequences. With its experience in disaster management, Japan is one of leaders in the area of engineering and planning that takes into account the need for disaster hazard reduction. Since the 1950s, Japan has spent 1% of its annual state budget on disaster prevention measures including the promotion of national environmental projects, improvements to weather forecasts and the development of anti-disaster measures. Consistent measures have meant that the negative consequences of natural disasters have been considerably mitigated throughout the country. In 1994, during the International Decade, Yokohama hosted the World

Conference on Natural Disaster Reduction, which adopted the Yokohama Strategy for a Safer World.

In 1999, with the completion of the International Decade and in order to promote global efforts to reduce the risk of natural disasters the UN General Assembly adopted an International Strategy. The ISDR aims at building disaster resilient communities by promoting increased awareness of the importance of disaster reduction as being an integral component of sustainable development, with the goal of reducing human, social, economic and environmental losses. Achievement of the goals and objectives of the Strategy will require the full involvement of all the actors concerned, including governments, regional and international organisations, civil society (including volunteers), the private sector and the scientific community. Therefore, on December 21, 2001, the UN General Assembly decided to celebrate the annual International Day for Disaster Reduction on the second Wednesday of October as a tool to promote a global culture of disaster reduction, including prevention, mitigation and preparedness.

The following World Conference on Disaster Reduction was held on January 18-22, 2005 in Kobe (Hyogo Prefecture), and adopted the Hyogo Declaration and the Framework for Action 2005-2015 setting out ways to build the resilience of nations and communities to disasters.

For Central Asian countries, resilience to these threats and challenges is an important aspect of regional cooperation. The region's economies, including various aspects of energy security, are based primarily on the use of transboundary water resources. The region has large-scale hydropower and water management systems.

For instance, in the Syr Darya basin, the capacity of all reservoirs (in excess of 28 km<sup>3</sup>) allows year-round runoff regulation, with 95% of the basin water resources used. In the Amu Darya basin, a third of the river flow is regulated. The high probability of devastating natural disasters, however, can have a tremendous impact on the safety and sustainability of water use. A waterworks failure or of a large dam would put people at risk and jeopardises the energy and food security of the region. The mountain areas of Tajikistan and Kyrgyzstan, which contribute a major part of the region's runoff and have many hydropower plants, are more susceptible to water-related natural disasters.

Joint actions to reduce the risk and damage of natural disasters caused by floods and drought is an important aspect of regional cooperation in the area of water resources management. These can be elaborated on the basis of international recommendations and so there is an increasing need for Central Asian countries' participation in international disaster reduction programmes and action plans. In the Central Asian context, actions should include the

various aspects of the security of water facilities and waterworks both under normal operating conditions and in the case of natural disasters.

Rivers like the Amu Darya and Syr Darya have dramatically different climatic zones and, consequently, different runoff generation conditions in different river segments. Safe water passage with extreme water consumption can only be ensured with the coordinated operation of reservoirs. However, Central Asian countries have yet to build a regional-level functioning system for the monitoring of risks and for the early warning of water-related natural disasters. It is, therefore, vital that a system based on a legal framework in the form of intergovernmental agreements is created.

Disasters related to weather, climate and water account for a significant portion of natural disasters; therefore, there is a need to focus on strengthening the national early warning systems for hydrometeorological hazards. To this end, the capabilities of the World Meteorological Organisation's global operational network for observations, monitoring, detection and forecasting of natural hazards should be used more broadly. There are early warning systems in the basins of the Danube, Rhine, Elbe and other international watercourses. Governments of coastal countries have taken the required measures to facilitate international information sharing in order to achieve the effective functioning of warning and caution systems. Data is exchanged using standardised messages, which enables more reliable and effective early warning compared to automated monitoring systems. The involvement of stakeholders in natural disaster risk reduction actions is achieved through training and clear communication.

It should be noted that the legal framework for this cooperation and the creation of an early disaster warning system in Central Asia is in place. First of all, the documents already adopted by the CIS should be relied on. These include the Agreement on Interaction in Prevention of and Response to Natural and Technological Emergencies (1993), the Agreement on Information Cooperation in the Area of Ecology and Environmental Protection (1998), the Agreement on the Basic Principles of Cooperation in Rational Use and Protection of Transboundary Water Bodies (1998), the Convention on Collective Environmental Security (2000), and the Agreement on Exchange of Information on Natural and Technological Emergencies, Information Interaction in Liquidation of Consequences and Assistance to Affected Population on Natural and Technological Emergencies (2003).

For Central Asian countries, the most important objective is to strengthen the partnership between the national authorities engaged in the prevention of and response to natural disasters. To enable an effective response to transboundary natural disasters and to eliminate their consequences, regional coordination of assistance to affected states, provision of material,

technical, medical services and other assistance should be ensured. To do this, the establishment of a regional fund to combat natural disasters should be considered in detail. Proceeds of this fund could also be spent on joint research on forecasting, notification and liquidation of consequences of natural disasters, the establishment of an early warning system and reconstruction of transboundary water management facilities and waterworks.

# Environmental and Investment Aspects in Transboundary Water Resources Projects

## **7.1. The environmental responsibility of international financial institutions and the Equator Principles**

Environmental responsibility is one of the principles of investment activities by international financial development institutions. When considering or participating in investment projects, they, above all, make sure that the planned economic activities neither make the state of the environment, working and living conditions worse nor endanger public health.

An additional complication is that the predominance of resource-intensive production is characteristic of post-Soviet countries. This farming method is associated with a high impact on the environment and its pollution in many cases affects neighbouring states, i.e. is of a transboundary nature.

The elimination of transboundary environmental risks is one of the priorities in cooperation between the EurAsEC and CIS countries in the area of environment protection. That is why investment projects that could affect the state of the neighbouring country's environment or the conditions in which it uses natural resources must take into account potential transboundary effects.

Water availability and sufficiency are main pre-conditions for the stable functioning of all economic sectors. Effective regulation of joint water use, primarily in agriculture and hydropower sectors, is an important area for international cooperation in Central Asia and the Caspian region. The predominance of resource-intensive production with a high impact on the environment in virtually all sectors is typical of these states. National-level efforts are not sufficient. Industrial waste recycling is still unresolved and an extremely urgent issue. Areas exposed to radioactive pollution with accumulated hazardous industrial waste pose an unacceptable risk to the population and ecosystems. The scale of erosion and loss of soil fertility are escalating. A significant portion of production facilities do not

meet environmental safety requirements and the quality of water in most transboundary water bodies does not meet regulatory requirements.

Environmental considerations are of increasing importance to international institutions, especially those operating in the cross-border context. In June 2003, the ten largest international banks declared that their investment decisions would be governed by the Equator Principles. These principles are so called because a project must comply equally with the requirements of national and international laws pertaining to environmental protection and industrial safety. The number of major lending institutions that have adopted the Equator Principles has reached sixty, and together they control 80-85% of the global project financing market.

The Equator Principles are based on the environmental protection and social standards adopted by the International Financial Corporation, a member of the World Bank. When a bank adopts the Equator Principles to assess the environmental and social impact of a project, this means that it assumes responsibility for the environmental safety of the project as early as the pre-investment phase. Thus international financial institutions are changing their policy of non-intervention to one of joint responsibility for efficient natural resources management and environmental protection. Unfortunately, the Equator Principles have yet to be adopted by banks in the former Soviet countries.

The Equator Principles apply to new project financing in all sectors with total capital costs of at least \$10 million. They form a benchmark against which financiers assess all the project's risks, including environmental, social and socio-economic issues. Recipients who do not meet these criteria must either repay their loans with a risk premium or review their business.

These criteria normally apply to sizable, complex or costly projects such as power plants, chemical facilities and mines and transport, environmental and telecommunications infrastructure.

Financial institutions adopting the Equator Principles must develop their own project-financing procedures covering various aspects of corporate social responsibility and effective and safe environmental management. In so doing, these institutions undertake to lend only to projects where there is a proven ability and willingness to comply with social and environmental protection measures. The bank must designate each project as either Category A, B or C (i.e. high, medium or low environmental or social risk). For Category A and B projects, the borrower is required to carry out a special environmental impact assessment. This approach enables the bank to eliminate or minimise the project's potential negative impact on ecosystems and the population. This is especially true for projects in the energy sector, primarily those developing fuel and energy resources including hydropower.

As mentioned above, there is a need for an objective assessment of threats to the environmental security of the host country and the region as a whole. Environment pollution often affects neighbouring countries, causing severe economic and social damage. However, efforts to solve cross-border environmental problems in the Caspian region and Central Asian countries are poorly coordinated. The environment does not often take centre stage in international relations, and there are no established procedures in place to resolve cross-border environmental issues. Interrelated problems are dealt with separately at national and regional levels, reducing the effectiveness of the response to environmental challenges. Therefore, regional cooperation must focus on formulating comprehensive environmental security policies. It is also clear that environmental security measures should be considered during the implementation of investment projects and programmes.

## **7.2. Investment-based Project Design and Effective Practical Arrangements for Integrated Water Resources Management**

An investment cycle comprises the activities necessary to commission a facility. The investment process includes concept design, engineering survey and design, building and installation, and, finally, commissioning. The concept design typically accounts for 5-10% of the project time and less than 1% of the investment. Engineering survey and design itself account for 10-20% of the project time and 2-6% of the investment. The actual building and installation account for 70-85% of the project time and 93-97% of the investment (including the cost of equipment). Lastly, commissioning accounts for 10% of the project time and 2-3% of the investment.

In aggregate, concept design and engineering survey and design take 15-30% of the project time and 3-7% of the investment. Although these two phases are not very lengthy and relatively inexpensive, they are the most important part of the investment cycle, determining the level of technology, long-term reliability, and the performance characteristics of the water facility. The design process lays the economic and quality groundwork for new facilities.

After the disintegration of the Soviet Union the investment activity in the economy declined, and so did the scale of construction, reconstruction and modernisation of energy facilities and related design work. Frequent reorganisations of regulatory agencies, denationalisation of design and research institutions and the ensuing loss of corpora of scientific and technical data, project designs and findings, had a grave effect on safety in energy. Take, for example, reconstruction of or emergencies at existing power plants and facilities – the lack of archive data makes rehabilitation projects far more expensive and lengthy.

Water facilities in the CIS are not sufficiently reliable, have severely depreciated assets fixed assets, high levels of energy loss and negative environmental impacts.

These problems of project activity persist in all post-Soviet countries. A fully-fledged project services market that would feature quality supply and solvent demand is yet to emerge in the EurAsEc and CIS countries. The existing public regulation of this process based on licensing of project activities helps to ensure that design organisations meet certain qualification requirements. However, this is where the state's involvement with this sector effectively stops. At the same time, most water and hydropower management initiatives are exceptionally science-intensive and require decisive government support. In advanced economies, design work is viewed as a technical aspect of national security. Research and design for the hydropower sector should be put on a modern managerial footing orchestrated by the state.

The countries in the Single Economic Space (Russia, Belarus and Kazakhstan), EurAsEC and the CIS still lack a system that would allow project work to be organised efficiently, not just in the water sector but in other sectors too. New approaches to financing R&D need to be developed, new organisational formats need to be established for design institutions, and more R&D professionals are needed. The legal framework for design and construction needs urgent revision, as many existing standards, rules, instructions and recommendations are obsolete. The role of the state in strengthening the project industry and preserving the corpora of project findings irrespective of the developer's status and the accessibility of data need to be clearly defined. Notably, the project industry no longer receives new specialists, as educational institutions in the Community do not train them. Skilling a highly professional designer takes 15-20 years. Given the current workforce shortage, the project industry may face major problems with the future application of investment. Therefore, an urgent designer training programme should be adopted within the EurAsEC or CIS framework, and Russia should assume the role of the originator of this process. The problem of R&D support for energy in EurAsEC and CIS countries has many facets and cannot be discussed in full within the framework of this publication. Given the urgency of this issue, we believe it should become a matter for broad discussions, with the resulting recommendations to be proposed to EurAsEC and CIS state authorities.

In Central Asia, 80-85% of all water resources are used by irrigated agriculture, which provides two-thirds of GDP and employs most of the population. Hydropower accounts for 27.3% of all electricity consumption. Industry and agriculture are the most energy-intensive sectors.

Therefore, the policy of hydropower resources management in cross-border river basins must be based on the premise that food safety cannot be achieved

without sustainable energy development. For Central Asia, hydropower and agriculture is an interrelated regional complex. If the perception of these two sectors as contradictory continues, competition for water will become bitter. The lengthy attempts over many years at creating a hydropower consortium in Central Asia have been inconclusive. We attribute this failure to the specific features of economic cooperation between the region's countries and weak integration mechanisms rather than political frictions. This warrants considering other mechanisms to manage the potential of Central Asian cross-border rivers and thus to ensure the food and energy security in the region.

A possible solution is to create agrarian-energy clusters at local, national and international levels, which would enable the mutually beneficial management of existing river basin organisations without disrupting the hydrographic unity of the basin. The basic preconditions for these clusters, i.e. interdependent water and energy infrastructures, are already in place. In relevant literature a cluster is defined as association of economic entities from closely related industries that can promote each other's competitiveness. A cluster is an inter-industry rather single-industry complex covering an area in which specialised suppliers, producers and consumers united by a common technological chain are all concentrated.

Over time, clusters can expand and even grow into other integration forms. This flexibility creates an important advantage over other forms of economic organisation. The cluster form of integration requires that natural factors such as climate change and its impact on water resources are taken into account. The negative consequences for hydropower and irrigation can be mitigated by modernising equipment and irrigation methods, a transition to energy and water conservation and improving the infrastructure for information and innovation exchange. This is one of the advantages of clusters, as they successfully accommodate innovative entities that are prompt in applying new technologies.

An agrarian-energy cluster is based on the premise that the water and hydropower services are ultimately consumed by a common user, namely, irrigation. A cluster unites a region's water, agricultural and hydropower organisations, which typically share common water and energy infrastructure. Regional development requires the construction of new water facilities, and not only for hydropower – the new facilities will be better placed to help the countries cope with natural disasters such as droughts and floods and mitigate water stress. These measures must be well coordinated and not detrimental to the water availability in neighbouring states and river basin ecosystems, and be in line with international law and obligations related to the protection and management of cross-border river resources.

# Conclusion

The joint management of water bodies and sharing of transboundary river resources is one of the biggest challenges facing in Central Asia. Addressing this challenge should be seen as a key aspect of integration between the region's countries along with food, energy and environmental security, transport infrastructure development, mutual investment as well as other areas of economic cooperation. On the one hand, regional water issues in joint management of water bodies and sharing of water resources cannot be considered separately from national water management, food security and energy strategies and, on the other hand, they must take into account basin-wide interests and the development of the region as a whole.

The uneven distribution and insufficiency of water resources in Central Asia in the context of ever-increasing water use cause competing demands for water between the countries' economic sectors at local, national and interstate levels. While gaining geopolitical significance, this factor has a decisive impact on many aspects of security in the region.

The CA countries have set up a relevant legal and institutional framework for interstate and regional cooperation such as intergovernmental agreements and regional organisations for the implementation of coordinated water and energy policies. Sharing of information on measures taken and planned to prevent, control and mitigate transboundary impacts on water resources and information on the quality and quantity of water resources is an important area of cooperation in Central Asia. The region's economy is significantly affected by natural disasters and extreme water-related events. Mitigation of the consequences of these calls for perfect forecasts that would underpin the development of warning and early response measures. The use of new equipment and devices including satellite telecommunications to collect, process and transmit data makes it possible to develop more reliable forecasts and make early warnings of hazardous weather and hydrological phenomena in transboundary river basins more effective. Timely dissemination of these forecasts among the region's countries is an important stage of disaster response readiness. The legal framework for this cooperation in Central Asia established by agreements between the CIS member states in this region is in place, but it is also important to provide a mechanism for the implementation of these agreements and for the coordination of efforts by the regional organisations involved in disaster mitigation.

River basin management should be aimed at a balanced use of surface and ground waters, which makes the role of planning and protection of water resources at all levels of government (local, national or interstate) more important. This is instrumental to meeting such goals as the efficient use of water resources, efficient water distribution at local, national and interstate levels and the environmental sustainability of river basins. The limited and vulnerable nature of water resources has necessitated a new approach to their assessment, development and management. This approach is based on the integration of water management plans and programmes within the framework of regional, national, economic, social and environmental policies.

Water management and hydropower projects are most capital-intensive. Risk mitigation and the successful implementation of projects call for clearly defined and auditable business processes as well as careful planning. To reduce the risks faced by large investment projects for the construction of water and hydropower facilities, one needs access to accurate and timely project information, regardless of time or place. In future, access to the required information may become one of major challenges to be faced when preparing and implementing investment projects.

International financial institutions' policies on projects that have cross-border effects on neighbouring states rely on such principles as the right to equitable and reasonable use of water resources and minimum damage.

The solution to the water problem in the Central Asian countries should be based on a number of priorities set by the international community, including the principle of reasonable and equitable use of transboundary river resources, and this is fundamental to regional cooperation. The protection of the quality and reduced consumption of water are regarded as the most urgent issues in water resources management in Central Asia.

# References

- Abdyrasulova N., Kravtsov, N. (2009) *Power Sector Management in Kyrgyzstan: Institutional and Practical Analysis*. Bishkek. UNISON.
- ADB (2010) Central Asia Atlas of Natural Resources. *Asian Development Bank*. Manila.
- Atlas (2011) *All about the World*. Guide. St. Petersburg: SZKEO.
- Bortnik V. et al (1991) Current Status and Possible Future of the Aral Sea. *Izvestiya Akademii Nauk*. Geographical Series. no. 4. Moscow: Nauka.
- Budagovsky A. (1992) Certain Aspects of Water and Environmental Problems of the Aral Sea and the Aral Sea Region. *Vodnye Resursy*. no. 2. Moscow: Nauka.
- CAC DRMI (2010) Risk Assessment for Central Asia and Caucasus: Desk Study Report. *Central Asia and Caucasus Disaster Risk Management Initiative*. Available at: [http://www.unisdr.org/files/11641\\_RMSIFINALrussmall.pdf](http://www.unisdr.org/files/11641_RMSIFINALrussmall.pdf)
- CAREC (2008) Materials of the Regional Environmental Centre for Central Asia. *Central Asia Regional Economic Cooperation*.
- CAREC (2009) Framework Action Plan on Energy. 8<sup>th</sup> Ministerial Conference on Central Asian Regional Economic Cooperation. October 14-16. Ulan Bator, Mongolia.
- CASA (2011) *Central Asia – South Asia Electricity Transmission and Trade (CASA-1000)*. Final report. SNS Lavalin International Inc. February.
- Chembarisov E., Shamsiyev F. (2008) *Multi-Stage Method of Assessment of the Status of Water Bodies. Desert Land Development Problems*. no. 3. Ashgabat.
- Chokin Sh. et al (1987) *Energy Sector and Electrification of Southern Kazakhstan*. Almaty: Nauka.
- Chub V., Myagkov S., Klimov, S. (2012) On Negative Impact of Arnasay-Aidar Lake System, Chardarya and Koksarai Reservoirs on Weather and Agroclimatic Resources of Samarkand, Jizakh, Syrdarya and Tashkent Oblasts. *Ekologichesky Vestnik - Ecologiya Habarnomasi*. no. 1. Tashkent.
- CIS ISC (2011a) *CIS Interstate Statistical Committee*. Available at: [www.cisstat.org](http://www.cisstat.org)
- CIS ISC (2011b) Collected Papers “Twenty Years of the Commonwealth of Independent States”. CIS Interstate Statistical Committee.
- CPSU CC (1988) On Measures for Fundamental Improvement of the Environmental and Sanitary Situation in the Aral Sea Region, Improvement

of Efficiency and Strengthening of Protection of Water and Land Resources in the Basin. Resolution of the CPSU CC and USSR Council of Ministers. no. 1110. September 19. *Central Committee of the Communist Party of the Soviet Union*.

Danilov-Danilyan V. (2009) *Global Water Resources and Prospects for Water Sector in Russia*. Moscow: Institute for Sustainable Development. Centre for Russian Environmental Policy.

Davydov Yu. (1925) Water Energy Reserves in Central Asia. Water Resources Management in Central Asia. *Vestnik Irrigatsii*. no. 7. Monthly journal. Central Asian water resources publication. Tashkent. July.

Deloitte (2012) Empowering Ideas 2011: A Look at Ten of the Emerging Issues in the Power and Utilities Sector. Available at: [http://www.deloitte.com/assets/Dcom-Global/Local%20Assets/Documents/Energy\\_Resources/10976A%20Empowering\\_sm5%20CC.PDF](http://www.deloitte.com/assets/Dcom-Global/Local%20Assets/Documents/Energy_Resources/10976A%20Empowering_sm5%20CC.PDF)

Dingelshet V. (1880) Water ownership and irrigation. Tiflis. Iv. Pitoyev printing house.

Dombrowsky I. (2008) *Integration in the Management of International Waters: Economic Perspectives on a Global Policy Discourse*. Global Governance: A Review of Multilateralism and International Organisations. 4 (14).

EDB (2008) Water and Energy Resources in Central Asia: Utilisation and Development Issues. Sector Report no. 2. April. *Eurasian Development Bank*. Almaty: RUAN.

EEA (2011) Europe's Environment – An Assessment of Assessments. *European Environment Agency*. Available at: [www.eea.europa.eu](http://www.eea.europa.eu)

EnergoFichtner (2011) Pre-Feasibility Study for Hydropower Plant in Tajikistan. Technical Report. Moscow.

FAO (2010) Forests and Climate Change in Eastern Europe and Central Asia. Food and Agriculture Organisation.

Frolov N. (1965) *Development and State of Land Improvement in the USSR*. Moscow: Kolos.

GEF (2003) Water and Environment Management Project. Subcomponent A1. Regional Report 2. Appendix D. Interstate Water Allocation in the Aral Sea: Past and Present. *GEF Agency*, Tashkent.

Glovatsky O. (2000) *Current Status and Prospects of Development of Pump Irrigation in the Republic of Uzbekistan*. Contribution of SANIIRI to the Development of Pump Irrigation in Central Asia and Reduction of Operation Costs. Contemporary Problems of Land Reclamation and Water Resources Management and their Solutions. Volume 1. Tashkent.

Horst M. (2002) *Possible Ways to Improve Water Management in Irrigated Agriculture in the Aral Sea Basin due to Climate Change*. Book "Dialogue on Water and Climate: Aral Sea Case Study. SIC. Tashkent.

- Ibragimov G. (2010) Nuclear Power in Central Asia: Is There a Future? *Index Bezopasnosti*. 4(95). Volume 16.
- ICARDA (2009) Support Project on Sustainable Land Management Research. Socioeconomic Analysis. *International Centre for Agricultural Research in the Dry Areas*. ICARDA Program for Central Asia and Caucasus. Tashkent.
- ICSS (2007) International Legal Aspects of Use of Hydropower Potential of Transboundary Rivers in Central Asia. Moscow: *Institute for Complex Strategic Studies*.
- Ikramov R. (2000) *Current Status of Water Management and Reclamation of Irrigated Lands in Uzbekistan*. Key improvement measures. Collection of research papers dedicated to the 75<sup>th</sup> anniversary of SANIIRI. Volume 3: reclamation of irrigated lands, water conservation and drainage operation. Available at: [www.cawater-info.net/library/rus/saniiri75\\_3.pdf](http://www.cawater-info.net/library/rus/saniiri75_3.pdf)
- Inter RAO UES. Investment Study for Kambarata GES-1 and GES-2. Republic of Kyrgyzstan. Task 2 – Project. Draft report on Progress of Sub-Task 2.1. Project History and Current Status. Volume 1 – Main Report. August 2008. EDF – Generation and Engineering Division.
- ISSA (2010) Central Asia. Geopolitics and the Region's Economy. Moscow: *Institute for Strategic Studies and Analysis*. Available at: [www.isoa.ru/docs/central\\_asia-book.pdf](http://www.isoa.ru/docs/central_asia-book.pdf)
- Ivanova L. (1992) Hydrological Aspects of the Aral Sea. *Vodnye Resursy*, no. 2. Moscow: Nauka.
- Kazansky P. (1895) *Rivers under Treaty*. Essays on History and Theory of International River Law. Kazan.
- Klimenko A. (2009) *Development Strategy of Shanghai Cooperation Organisation: Defense and Security Issues*. Moscow: Institute for Far Eastern Studies under Russian Academy of Sciences.
- Klimenko B. (1969) International Rivers. Moscow: *Mezhdunarodnye Otnosheniya*.
- Kondratyev V. (2011) Infrastructure and Economic Growth. *Mirovaya Ekonomika i Mezhdunarodnye Otnosheniya*, no. 11. November. Moscow: Nauka.
- Kuznetsov N. (1991) *Geographic and Environmental Aspects of Hydrological Functions of the Aral Sea*. Proceedings of the USSR Academy of Sciences. Geographical Series. no. 4. Moscow: Nauka.
- Lutz W. (2010) *Emerging Population Issues in Eastern Europe and Central Asia. Research Gaps on Demographic Trends, Human Capital and Climate Change*. UNFPA.
- Lvovich M., Tsygelnaya I. (1979) *Problems of Future Use of Local Water Resources in Central Asia and the Aral Sea*. Collected research papers

“Changing Environmental Conditions in Areas of Transportation and Distribution of the Siberian Rivers”. Almaty: Kitap.

Molotov S. (2010) *Regional Concept of Fuel and Energy Resources Use Efficiency Improvement Policy in Central Asia for 2011-2015*. Moscow: Centre for Energy Policy.

Obrezkov V., Gokhman A. (1973) *Hydropower plants in Electric Power Systems*. Moscow: Energiya.

OECD (2006) *Mechanisms for Managing Public Environmental Expenditure in Selected OECD Countries*. Organisation for Economic Cooperation and Development. Paris.

RK (2011) *Kazakhstan in 2010. Statistical Yearbook*. Republic of Kazakhstan. Statistics Agency. Astana.

Royal Haskoning (2003) *Water and Environmental Management Project. Sub-component A1. Regional Report no. 2. Appendix D. Interstate water allocation in the Aral Sea: the Past and Present*. Tashkent.

RT (2001) *National strategy and action plan for sustainable development of mountain areas of the Republic of Tajikistan*. Dushanbe.

RT (2007) *Strategy for Development of Small-Scale Hydropower in Tajikistan*. Dushanbe.

RT (2008) *The Second National Communication of the Republic of Tajikistan under the United Nations Framework Convention on Climate Change*. Dushanbe.

RU (1975) *Irrigation of Uzbekistan. Volume 2. Current status and prospects of development of irrigation in the Syr Darya river basin*. Republic of Uzbekistan. Tashkent.

RU (1979) *Irrigation of Uzbekistan. Volume 3. Current status and prospects of development of irrigation in the Amu Darya river basin*. Republic of Uzbekistan. Tashkent.

RU (2008) *National Report on Environmental Situation and Utilisation of Natural Resources in the Republic of Uzbekistan – 2008. Retrospective Analysis for 1988-2007*. Republic of Uzbekistan. Tashkent.

RU (2011a) *Water economy of Uzbekistan*. Republic of Uzbekistan. Tashkent.

RU (2011b) *Republic of Uzbekistan*. Investment newsletter. November 25. Available at: [uz.mofcom.gov.cn](http://uz.mofcom.gov.cn).

Rules (1966) *The Helsinki Rules on the Uses of the Waters of International Rivers*. August, 20.

Sarsembekov T. et al (2004) *Use and Protection of Transboundary Rivers in Central Asia*. Almaty: Atamura.

Schultz W. (1965) *Rivers of Central Asia*. Part 1-2. Leningrad.

- Soyuzgiprovodkhoz (1989) Integrated Aral Sea Water and Land Use Arrangement. Key provisions. Moscow: Soyuzvodproekt, Soyuzgiprovodkhoz.
- SPECA (2004) Strengthening Cooperation for Rational and Efficient Use of Water and Energy Resources of Central Asia. *Special Program for Economies of Central Asia*. New York.
- Troitsky E. (2010) Multi-Vector Policy, Willy-Nilly. *Mezhdunarodnye Protsessy* (International Relations and World Politics Theory Journal). Volume 8. 3(24). September – December. Available at: [www.intertrends.ru/twenty-four](http://www.intertrends.ru/twenty-four)
- UN (1997) The UN Convention on the Law of Non-Navigational Uses of International Watercourses. *United Nations*. Available at: [www.un.treaty.org](http://www.un.treaty.org)
- UN (2004) Tajikistan. Environmental Performance Reviews Series. no. 21. *United Nations*. New York and Geneva.
- UN (2008) Kazakhstan. Second Review. Environmental Performance Reviews Series. no. 27. *United Nations*. New York and Geneva.
- UN (2009) Kyrgyzstan. Second Review. Environmental Performance Review Series. no. 28. UNECE. Committee on Environmental Policy. New York, Geneva.
- UN (2010) Uzbekistan. Second Review. Environmental Performance Reviews Series. no. 29. *United Nations*. New York, Geneva.
- UN (2011a) Second Assessment of Transboundary Rivers, Lakes and Groundwater. *United Nations*. New York, Geneva.
- UN (2011b) United Nations Department of Economic and Social Affairs, Population Division. *World Population Prospects: The 2010 Revision*.
- UN (2012) Convention and Statute on the Regime of Navigable Waterways of International Concern. Available at: [www.un.treaty.org](http://www.un.treaty.org)
- UN DESA (2011) *United Nations Department of Economic and Social Affairs Population Division*. World population prospects: The 2010 revision.
- UNCTAD (2011) Handbook of Statistics. *United Nations Conference on Trade and Development*.
- UNDP (2005) Report on Human Development in Central Asia. UNDP Regional Bureau for Europe and the CIS. *United Nations Development Program*. Bratislava.
- UNDP (2006) Human Development Report 2006. Beyond Scarcity: Power, Poverty and the Global Water Crisis. *United Nations Development Program*. Moscow: Tsely Mir Publishing House.
- UNDP (2011) Human Development Report 2011. Sustainability and Equity: A Better Future for All. *United Nations Development Program*. Available at: <http://hdr.undp.org>.
- UNECE (2007) Dam Safety in Central Asia: Capacity-Building and Regional Cooperation Water Series. no. 5. *United Nations Economic Commission for Europe*. Geneva.

- UNECE (2009) Transboundary Flood Risk Management: Experiences from the UNECE region. *United Nations Economic Commission for Europe*. Geneva.
- UNECE (2011a) Our Waters: Joining Hands Across Borders. Second Assessment of Transboundary Rivers, Lakes and Groundwater. *United Nations Economic Commission for Europe*. Geneva.
- UNECE (2011b) Second Assessment of Transboundary Rivers, Lakes and Groundwaters. UNECE. Convention on the Protection and Use of Transboundary Watercourses and International Lakes. New York and Geneva.
- UNEP (2002) GEO-3: Global Environment Outlook 3. Past, present and future perspectives. *United Nations Environment Programme*.
- UNEP (2005) Environment and Security. Transforming Risks into Cooperation. Central Asia. Ferghana-Osh-Khujand. UNEP, UNDP, OSCE. *United Nations Environment Program*.
- UNEP (2008) Environment and Security. Transforming risks into cooperation. The case of the Eastern Caspian Region. *United Nations Environment Programme*. UNEP, UNDP, UNECE, OSCE, REC, NATO.
- UNEP (2011) Environment and Security in the Amu Darya Basin. UNEP, UNDP, UNECE, OSCE, REC, NATO. Available at: [www.unep.org](http://www.unep.org); [www.envsec.org](http://www.envsec.org)
- UNESCO (2010) Use of Renewable Energy Sources in Central Asia. *United Nations Educational, Scientific and Cultural Organisation*. Almaty.
- USSR (1990) Project "Seas of the USSR". Hydrometeorology and hydrochemistry of the USSR seas. Volume VII. Aral Sea. Leningrad: Gidrometeoizdat.
- Uzbekenergo (2004) Power Sector of Uzbekistan. Overview. Uzbekenergo. Finnmap. Tashkent.
- Volynov A., Zabelin V., Kiyatkin, A., Luzhneva M. (1980) *Irrigation in Central Asia and Kazakhstan*. Moscow: Kolos.
- WB (2010) Load Dispatch and System Operation Study for Central Asian Power System. Report. Mercados – Energy Markets International (Spain). *World Bank*. October.
- WMO (1992) WMO and UNESCO International Glossary of Hydrology. *World Meteorological Organisation*. Geneva.
- WMO (2005) Report of the GCOS Regional Workshop for Central Asia on Improving Observing Systems for Climate. Almaty, Kazakhstan. May 24-26. *World Meteorological Organisation*.
- WMO, UNESCO (1997) Water resources assessment. Handbook for Review of National Capabilities. *World Meteorological Organisation, United Nations Educational, Scientific and Cultural Organisation*.
- CAwater (2012) *Portal of Knowledge for Water and Environmental Issues in Central Asia*. Available at: [www.cawater-info.net](http://www.cawater-info.net)

- Yasinskiy V., Mironenkov A., Sarsembekov T. (2009) Investment and the Equator Principles. *Mirovaya Energetika*. 6 (65). Moscow.
- Yasinskiy V., Mironenkov A., Sarsembekov T. (2010) *Transboundary River Resources in Regional Cooperation in Central Asia*. Eurasian Development Bank. Almaty: RUAN.
- Yasinskiy V., Mironenkov A., Sarsembekov T. (2010b) Balance of Interests in the Use of Hydropower Resources of Transboundary Rivers – State of Sustainable Development of Central Asian countries. *Akademiya Energetiki*. 4 (36). St. Petersburg.
- Yasinskiy V., Mironenkov A., Sarsembekov T. (2011) *Investment Priorities of Cooperation in Central Asian Transboundary River Basins*. Eurasian Development Bank. Almaty: RUAN.
- Yasinskiy V., Mironenkov A., Sarsembekov T. Customs Union and Investment Prospects of Energy Integration of the Eurasian Economic Community.
- Yasinskiy V., Mironenkov A., Steklov Yu, Sarsembekov T. (2011) *International Practice and Problems of Cooperation of Hydropower Development in Transboundary River Basins*. Eurasian Development Bank. Almaty: RUAN.
- Zhukov S., Reznikov O. (2001) *Central Asia in Socio-Economic Structures of the Modern World*. Moscow: Moscow Public Science Foundation.
- Zoï environment network (2009) *Climate Change in Central Asia*. Geneva.
- Zoï environment network (2011) *Biodiversity in Central Asia: A Visual Synthesis*. Geneva.

ISBN 978-601-7151-29-4



9 786017 151294