GEF AGENCY of the IFAS
ARAL SEA BASIN PROGRAM

Water and Environmental Management Project

Sub-component A1

National and Regional Water and Salt Management Plans

JOINT REPORT No. 2
(FINAL)

BASIN WATER AND SALT BALANCES AND THEIR IMPLICATIONS FOR NATIONAL AND REGIONAL PLANNING

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GLOSSARY

ASB	Aral Sea Basin
ASBOM	Aral Sea Basin Optimisation Model
BVO	River Basin Authority (Russian acronym)
EC-IFAS	Executive Committee of IFAS
IC/RWG	International Consultant/Regional Working Group
ICWC	Interstate Commission for Water Coordination
IFAS	International Fund for Saving the Aral Sea
IOPE	Independent Panel of Experts
LAS	Larger Aral Sea
NAS	Northern part of the Aral Sea
NSDC	Naryn-Syr Darya Cascade
NWG	National Working Group.
PMCU	Project Management and Coordination Unit
RWG	Regional Working Group.
SANIGMI	Central Asia Scientific Institute of Hydrology and Meteorology
SIC-ICWC	Scientific Information Centre of ICWC
USAID	US Agency for International Development
WARMAP-2	Water Resources Management and Agricultural Production in the Central Asian Republics – Phase 2
WAS	Western Part of the Aral Sea

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APPENDICES

1. PREFACE

1. Joint Report 2 concludes Phase V of the WEMP A1 project, and discusses Basin water and salt balances and their implications for national and regional planning in accordance with the Terms of Reference, which read as follows: 'This report presents the results of the first step in the integration of regional and national perspectives (task R8/N8). The report would present short and long-term water salt balances for the various planning zones and for the basin as a whole for various water supply and demand scenarios under different assumptions for river salinity and flow targets, different allocations to rivers, deltas and Aral Sea shore, and alternative development scenarios of the irrigation sector. It is envisioned that only a limited number of these will prove to be interesting and useful for evaluating their implications for the choice of strategy options and measures at the national level, and when evaluating different water allocation mechanisms and rules. The report would seek political guidance on a number of strategic choices and on the proposed conceptual and economic planning framework for Phase VI (see section 3):

a) forecasted and improved medium (10 years) and long-term (25 years) water and salt balances for planning zones determined with the basin simulation models and based on the output described in the National Report 1 and Regional Report 2; and the predictive capacity, with an emphasis on hydrogeology, to forecast salinity processes and trends in critical areas and salt loads to transboundary river water over a longer period of time;

b) future available national and transboundary water resources , their variability in terms of quantity and salinity, and an evaluation of the implication of this variability for the evaluation of alternative water allocation principles and criteria (from Regional Report 2);

c) alternative water and salt balances that meet long-term sustainability criteria (from Regional Interim Report 2) and the implications for water availability (national and transboundary water) to the states;

d) clear description of the following information that is necessary for decision making and giving guidance to the national and regional project teams for the preparation of the next reports:

   i) alternative long-term strategic salinity standards at different locations along the Amu Darya and Syr Darya and their implications in terms of costs of salinity and national water availability;

   ii) alternative sustainable hydrologic regimes for water allocation to satisfy sanitary and ecological demands of the transboundary rivers and the delta areas;

   iii) alternative water demand and discharge limitations or targets based on water and salt balances taking into account alternative river flow and salinity targets and sustainable environmental water demands (the sanitary and ecological water demands of transboundary rivers, deltas, and Aral Sea shore);

iv) the results, in terms of transboundary water allocation to each state, of an evaluation of the application of: (i) alternative principles and criteria for inter-state water allocation and (ii) alternative regional salinity and environmental standards;

v) results of review of existing agreements for national and inter-state water allocation;

vi) evaluated alternative principles and criteria that might be adopted for inter-state water allocation;

vii) conclusions on the relative advantages and disadvantages of alternative principles and criteria, separately are in combination, as a basis for transboundary water allocation;

e) on the basis of consolidating the above results, proposals by the Consultant for:

viii) adoption of the decision on the proper level: (i) principles and criteria for transboundary water allocation, (ii) transboundary river flow and salinity standards and sanitary and environmental flows, and (iii) the results of application of these principles, criteria and standards in terms of transboundary water allocation and total national water availability;

ix) measures that could be implemented on regional and national level to arrive at a long-term sustainable water and salt balance in the Amu Darya and Syr Darya basins that meet regional salinity and ecological criteria;

f) a coherent conceptual and economic framework for the formulation and evaluation of alternative regional and national policy and strategy options and tradeoffs in a uniform way from a basin perspective with the main features and direction of alternative the policies and strategies.'

2. INTRODUCTION

2. Sub-component A1 of the Water and Environmental Management Project (WEMP) has the overall objective of developing water and salt management plans for the Aral Sea Basin. One aim is to provide a consistent set of policies, strategies and action programs for the Basin relating to:

- water conservation and reduction of soil salinity;
- rehabilitation and improvement of irrigation and drainage infrastructure; and
- improvement of the operation and maintenance of main and on-farm systems.

3. The content and structure of Joint Report 2 has been determined in consultation with the PMCU, the National Working Group team leaders and the ICWC Working Group members. It presents basic information on the economies of the five countries and on the available water resources, considers the National water and salt management plans produced to date, and then presents and evaluates various water and salt balances depending on options for future regional development and water and salt management. The report goes on to consider ways in which the joint management of water resources can be improved and the relevant institutions strengthened.

4. Coming as it does at the end of Phase V of Subcomponent A1, Joint Report 2 is envisaged in the Project ToR as representing the first step in the integration of regional and national perspectives, and has the aim of seeking guidance from decision-makers on a number of strategic choices and on the proposed framework for Phase VI of the project. Essentially, its aim is to set out the guidelines and indicate the directions for the preparation of National Reports 2 and Regional Report 3, which are the end products of WEMP A1.

5. The Project Terms of Reference envisage National Reports 2 as being revised and elaborated versions of National Reports 1. The draft of Joint Report 2 (see below) demonstrated that, from the regional perspective of needs and constraints, it is possible to consolidate the national plans within certain boundary conditions relating to water resources availability and water demand. Therefore, proposals are also given on desirable revisions to the National reports in order that they present water and salt management plans that are consistent and that there are possibilities to integrate them into a Basin framework.

6. Joint Report 2 also considers major issues to be addressed in the completion of Regional Report 3. The guidance flowing from the consideration of these major issues will provide the direction for Phase VI and for the content of Regional Report 3 as outlined in the Terms of Reference.

7. A draft of the Report, prepared in June 2002, was circulated to all states prior to a special ICWC meeting held in Almaty on 14-15 June 2002, where this draft was presented and discussed. Subsequently, comments were received from:

- PMCU
- ICWC Working Group
- The National Working Group of Uzbekistan

- The Committee of Water Resources of the Ministry of Natural Resources and Nature Protection of the Republic of Kazakhstan
- Department of Water Resources of the Ministry of Agriculture and Water Resources of the Republic of Kyrgyzstan
- Ministry of Water Resources, Turkmenistan
- SIC ICWC
- BVO Syr Darya
- SIC SDC

8. In producing this final version of Joint Report 2, the draft has been amended in accordance with those comments where this could be readily done and the suggested changes were appropriate and acceptable for the ICWC Working Group and the Consultant. In addition to detailed amendments, the most significant changes occur in Chapter 7, which is now titled ‘Water and Salt Balances and Their Implications for National and Regional Planning’.

3. NATIONAL ECONOMIES

3.1 Sources of Data

9. The values for economic indicators and agricultural productivity have been obtained from National Working Group reports. This applies in the cases of both past years and projections for future years. The data generally relate to high growth scenarios ('Revitalisation' and 'Composite' Scenarios), which assume a free market approach to economic management, and increased investment and economic activity. The Revitalisation Scenario assumes that these changes occur rapidly, while the Composite Scenario assumes a slower rate.

10. The data are summarised in the following sections. Projections for the years 2010 and 2025 are shown shaded.

3.2 Economic Indicators

3.2.1 Population

11. The population data are summarized in Table 1 for the nations as a whole and for the sections of each country within the Aral Sea Basin.

Table 1: Past and Projected Future National and Aral Sea Basin* Populations (Millions)

Year	Kazakhstan	Kyrgyzstan	Tadjikistan	Turkmenistan	Uzbekistan	Total
1990	16.7	4.3	5.4	3.7	20.3	50.4
	2.5	*1.8*	*5.4*	*3.7*	*20.3*	*33.7*
1995	16.0	4.6	5.9	4.6	22.9	54.0
	2.5	*2.0*	*5.9*	*4.6*	*22.9*	*37.9*
2000	14.9	4.9	6.1	5.4	24.3	55.6
	2.6	*2.2*	*6.1*	*5.4*	*24.3*	*40.6*
2010	15.7	7.6	7.3	8.6	30.1	69.3
	3.1	*2.7*	*7.3*	*8.6*	*30.1*	*51.8*
2025	25.9	8.4	9.0	13.1	40.3	96.7
	4.8	*3.5*	*9.0*	*13.1*	*40.3*	*70.7*

* The population of the regions of each country within the Aral Sea Basin is shown in italics
Source: NWG reports

12. There is a wide disparity in the indicated rates of population growth. For example, the assumed annual growth rate in the period 2000-25 ranges from 1.6% for Tadjikistan to 3.6% for Turkmenistan. On the basis of these projections, the population in the Aral Sea Basin will rise from the current figure of a little over 40 million to about 70 million by 2025, i.e. an overall increase of 75% or an annual growth rate of 2.25%.

13. The production of accurate population predictions requires considerable knowledge of demographics and the use of specialist projection techniques which take account of trends in fertility rates, age distribution, life expectancy, marriage age, family size, etc. Projections for the five Central Asian nations for 2025 prepared by the special

United Nations Population Division are shown in Table 2 for information. On the basis of those figures, the adjusted total for the Aral Sea Basin in 2025 would represent a modest 1.3% average annual growth rate.

Table 2. United Nations 2025 Population Projections (These figures were not used in NWG calculations)

Country	UN Projected 2025 Population (million)
Kazakhstan	16.1
Kyrgyzstan	6.5
Tadjikistan	8.1
Turkmenistan	6.8
Uzbekistan	34.2

Source: UN 'World Population Prospects: The 2000 Revision'

3.2.2 Gross Domestic Product (GDP)

14. GDP data have been taken from NWG Reports, and are shown in Table 3 in terms of the total national GDP and on a per capita basis.

Table 3. Past and Projected National GDP ($US billion) and Per Capita GDP ($US)

Year	Kazakhstan	Kyrgyzstan	Tadjikistan	Turkmenistan	Uzbekistan
1990	5.1 *2,000*	14.0 *3,200*	1.9 *320*	11.4 *3,000*	14.6 *720*
1995	3.5 *1,400*	1.5 *320*	0.6 *100*	5.9 *1,100*	14.4 *630*
2000	3.0 *1,150*	1.4 *270*	0.8 *130*	22.9 *4,300*	17.4 *710*
2010	5.1 *1,600*	1.5 *300*	1.8 *240*	127 *14,800*	33.5 *1,110*
2025	7.7 *1,600*	2.6 *400*	#	207 *15,800*	68.0 *1,700*

Per capita GDP shown in italics
\# no projections made
Source: NWG Reports

15. Again there is a wide disparity in the perceived future rates of growth between the countries. The Kyrgyzstan NWG foresees only about 50% increase in per capita GDP for that country by 2025, whereas in the case of Turkmenistan the projected increase is about 370%. This relatively high value is no doubt influenced by likely increases in oil and gas revenues. In the case of Uzbekistan an increase in per capita GDP of 240% is projected.

3.3 Agricultural Sector

3.3.1 Sectoral Distribution of GDP

Table 4: Past and Projected Future Proportion of GDP from Agricultural Sector (%)

Year	Kazakhstan	Kyrgyzstan	Tadjikistan	Turkmenistan	Uzbekistan
1990	34	45	25	31	33
1995	19	45	21	16	32
2000	15	38	23	26	26
2010	15	50	30	15	24
2025	15	50	#	15	20

no projections made
Source: NWG Reports

16. The proportion of total national GDP contributed by the agricultural sector is shown in Table 4. The contribution comes almost entirely from irrigated agriculture. The importance of agriculture is seen to be greatest in Kyrgyzstan, where it is projected to increase. The sector is also projected to increase in importance in Tadjikistan. In the other three countries the sector is forecast to become relatively less important, particularly in Turkmenistan.

3.3.2 Irrigated Area

17. Information provided by the NWGs on the extent of irrigation, both past and projected into the future, is shown in Table 5.

Table 5: Past and Projected Future Extent of Irrigated Area ('000 ha)

Year	Kazakhstan	Kyrgyzstan	Tadjikistan	Turkmenistan	Uzbekistan	Total
1990	782	410	706	1,329	4,222	7,449
1995	786	416	719	1,736	4,298	7,955
2000	786	415	719	1,714	4,259	8,101
2010	806	434	1,064	2,240	4,355	8,899
2025	815	471	1,188	2,778	6,441	11,693

Source: NWG Reports

18. Relatively minor increases in irrigated area are projected in Kazakhstan, Kyrgyzstan and Tadjikistan. In the two countries with the largest irrigated areas – Turkmenistan and Uzbekistan – the NWGs project significant increases by 2025, although such large increases are seen by the NWGs concerned only as possible outcomes under ideal funding conditions which would lead to high levels of water productivity.

3.3.3 Saline Areas

19. The proportion of the irrigated lands in the Aral Sea Basin in which salinity levels in the top metre of soil classed as moderate or severe has increased substantially in recent years, with 30% of the whole irrigated area in the Basin falling into those classes in 1999. The change in the ten years from 1990 to 1999 is illustrated in Table 6.

Table 6: Extent of Saline Irrigated Lands in the Aral Sea Basin ('000 ha)

Plannig Zone	Irrigated area in 1990	Areas of slightly, moderately and severe saline lands								% increase 1990-1999
		1990			Total	1999			Total	
		Slight	Moderate	Severe		Slight	Moderate	Severe		
Syr Darya River Basin										
Kyrgyzstan (total)	410	13	5	4	22	12	5	4	21	-2
Uzbekistan	1860	603	151	48	802	465	250	80	794	-1
Andijan	280	23	3		26	12	12		24	-8
Djizak	290	157	65	25	247	140	77	26	243	-1
Namangan-Syr Darya	30	11	2		13	20	8		28	114
Namangan-Naryn	240	43	1	1	45	7	3	1	11	-75
Syr Darya	290	225	45	13	282	174	81	23	278	-1
Tashkent-Syr Darya	40	3			3	6			6	85
Tashkent-Chirchik	340	1	1		3	2	1		3	20
Ferghana	350	141	33	8	182	104	67	30	200	10
Tadjikistan	250	47	11	5	62	44	11	5	60	-2
Kazakhstan	780		55	64	119	128	128	87	342	187
Total for the Syr Darya Basin	3,300	663	221	121	1,005	650	393	177	1,219	21
Amu Draya Basin										
Tadjikistan	690	29	16	3	47	29	16	3	47	-1
Uzbekistan	2400	900	403	103	1406	867	500	138	1,504	7
Bukhara	330	230	65	25	320	159	77	26	262	-18
Kashkadarya	190	41	10	3	55	36	12	4	51	-6
Karshi	290	68	31	13	112	135	34	12	180	61
Navoi	120	75	21	5	100	68	37	5	110	10
Samarkand	400	15	3	2	21	8	5	1	14	-33
Surkhandarya	320	66	42	2	110	85	55	6	145	32
Khorezm	250	140	80	20	241	122	113	35	270	12
Karakalpakstan-South	140	74	35	16	125	65	46	20	130	5
Karakalpakstan-North	360	191	116	17	323	189	123	28	340	5
Total for Tadjikistan and Uzbekistan	3,090	929	418	106	1,453	895	516	141	1,551	6
Turkmenistan		457	478	158	1093	478	969	197	1644	50
Dashoguz	330**	106	167	52	325	48	300	60	408	25
Akhal	330**	109	125	37	271	108	311	70	489	80
Mary	370**	109	107	31	247	183	160	54	397	61
Lebap	260**	129	74	29	232	132	125	10	267	15
Balkan	20**	3	5	9	17	7	73	3	83	374
Total for the Amu Darya Basin	4,810	1,386	896	264	2,546	1,373	1,485	338	3,195	80

* 1994

** Area of irrigated lands in Turkmenistan has significantly increased during 1990 -1999

20. Indications of the future extent of saline irrigated lands will be provided by the results of studies using the water and salt balance models developed by the Regional Working Group.

3.3.4 Agricultural Production

21. The values for the most important crops, cotton and wheat, are shown below in Table 7 and Table 8 in terms of both gross production and production per hectare.

Table 7: Cotton - Past and Projected Future Gross Production ('000t) and Average Annual Yields* (t/ha) in Central Asia

Year	Kazakhstan	Kyrgyzstan	Tadjikistan	Turkmenistan	Uzbekistan
1990	323 *2.7*	218 *2.7*	377 *2.8*	927 *2.3*	4,900 *2.8*
1995	154 *2.2*	88 *2.3*	314 *1.4*	1,035 *2.2*	3,438 *2.6*
2000	296 *1.9*	91 *2.6*	330 *1.4*	1,407 *2.2*	3,280 *2.2*
2010	320 *2.8*	107 *2.9*	810 *2.8*	3,000 *4.5*	4,500 *3.2*
2025	330 *3.0*	140 *3.0*	1,050 *3.0*	3,600 *4.7*	7,250 *5.0*

* Average annual yields shown in italics
Source: NWG Reports

22. It can be seen that the first three countries all predict increases in average cotton yield to 3.0 t/ha by 2025. This value is only 10% greater than the yields experienced in 1990. In the cases of Turkmenistan and Uzbekistan, the predicted 2025 cotton yields are substantially higher at 4.7 and 5.0 t/ha respectively. These are roughly double the current average yield levels, and also the 1990 yield levels.

Table 8: Wheat - Past and Projected Future Gross Production ('000t) and Average Annual Yields* (t/ha) in Central Asia

Year	Kazakhstan	Kyrgyzstan	Tadjikistan	Turkmenistan	Uzbekistan	Total
1990	488 *3.2*	234 *2.8*	28 *1.4*	408 *2.2*	247 *2.6*	1,405
1995	56 *0.8*	643 *2.2*	295 *1.1*	453 *2.1*	2,485 *2.1*	3,932
2000	85 *1.2*	274 *2.4*	620 *1.2*	1,705 *2.3*	2,805 *3.1*	5,489
2010	200 *3.5*	560 *2.6*	1,100 *2.6*	3,000 *2.5*	4,700 *3.5*	9,560
2025	250 *4.1*	720 *2.7*	1,580 *2.7*	4,500 *2.8*	8,200 *5.0*	15,250

* Average annual yields shown in italics
Source: NWG Reports

23. At 4.1 t/ha and 5.0 t/ha, the wheat yield forecasts for 2025 in Kazakhstan and Uzbekistan respectively are substantially higher than current or past levels. With these levels combined with the large forecast increase in irrigated area, gross wheat production in Uzbekistan is predicted to triple between now and 2025. Similarly, total wheat production in the Central Asian countries overall is projected to roughly triple by 2025.

24. Details of past and projected future production of all crops are presented in Appendix 1. The crops include wheat, rice, cotton, maize, potatoes, vegetables, melons and gourds, and fruits.

3.3.5 Water Productivity of Main Crops

25. Indications for values representing average water use for the main crops in typical older irrigation areas in the mid-plains (except rice), together with field application efficiencies, are shown in Table 9.

Table 9: Water Use of Main Crops (Typical Older Area)

Crop	Biological Crop Requirement ('000 m^3/ha)	Average Volume Needed at Boundary of Field ('000 m^3/ha)	Field Application Efficiency
Cotton	6,200	8,500	0.73
Winter wheat	2,500	3,400	0.73
Rice (delta areas)	15,000	34,900	0.43
Fruit	8,500	11,600	0.73

Source: NWG reports

26. The values shown are indications for volumes applied to the field. Also shown are the biological plant requirements. A comparison of the two gives a measure of the efficiency of the irrigation application process. The low field application efficiency for rice is due to the large volumes lost by in-field seepage during several months when the rice fields are inundated. Even higher volumes are applied in some other areas, application rates of 20,000 m^3/ha or more being common in the delta areas.

27. The results of economic studies by the RWG into the relative benefits of the various main crops are shown in Table 10. They are presented in terms both of the (i) net benefits per hectare of crop, and (ii) net benefits per thousand cubic metres of irrigation water diverted from the source rivers, for three areas that are representative of conditions in a large part of the Basin. Net benefits are calculated as the difference between annual gross benefits and annual variable costs of production. Gross benefits are calculated using current crop yields and economic prices for the production. Variable costs are also given in economic prices.

Table 10: Current Economic Benefits of Major Crops in Representative Areas

Zones	Cotton			Winter Wheat			Rice			Fruits			Vegetables		
	Yield	Net benefit		Yield	Net benefit		Yield	Net benefit		Yield	Net benefit		Yield	Net benefit	
	t/ha	\$/ha	\$/ th.m^3	t/ha	\$/ha	\$/ th.m^3	t/ha	\$/ha	\$/ th.m^3	t/ha	\$/ha	\$/ th.m^3	t/ha	\$/ha	\$/ th.m^3
Upper reaches															
Namangan/ Uzbekistan	2.4	230	17	3.2	-40	-7	2.0	-70	-2	7	325	25	17	670	38
Tadjikistan				2.7	72	13				6	280	21	17	630	37
Old/ middle-plain zones															
Chakir/Kazakhstan	2.2	160	14	2.0	-160	-34	3.0	140	4	7	320	28	14	480	32
Fergana/Uzbekistan	2.6	300	21	3.4	-15	-3	2.9	120	4	7	325	25	15	550	32
Mary/Turkmenistan	1.8	120	8	2.2	-135	-25	1.8	-120	-3	5	225	16	10	240	14
Osh/Kyrgyzstan	2.6	310	22	3.3	82	16	2.7	77	2	9	450	34	10	440	25
New/middle-plain zones															
Hunger steppe/ Kazakstan	1.9	55	6	1.9	-174	-3,5	2.5	35	2				10	265	21
Syr Darya/Uzbekistn	1.5			2.2	-143	-25	1.8	-110	-4				11	320	25
Balkan/ Turkmenistan	1.6	50	5	2.0	-155	-30	1.4	-205	-7	3	95	10	10	235	17
Old lower reaches															
Khorezm/ Uzbekistan	2.5	370	25	3.8	40	7	3.5	240	6	6	260	20	15	525	33
Dashoguz/ Turkmenistan	1.7	85	6	2.1	-145	-25	2.0	-84	-2	6	290	22	10	240	17
New lower reaches															
Karakalpakstan/ Uzbekistan	1.3	-80	-7	2.0	-120	-30	1.8	-165	-5.5	3	75	6	9	180	12

Source: RWG studies based on data presented by NWGs and WUFMAS

28. The results suggest that it is questionable if it is possible to grow wheat (average indicators) in an economical way, except in those areas where variable costs are low and crop yields high. Growing of fruit and vegetables is shown to be the most profitable enterprise, but obviously the scope for these crops is limited by the size of the local market. Cotton and rice are shown to be profitable crops where reasonable yields are obtained, but cotton gives a much greater return per unit volume of water than rice because it requires less water. It is clear that cotton is by far the most economic field crop for most areas.

29. All field crops show low or negative net economic returns in areas where yields are low, which include some of the areas that were developed from the 1960s onwards.

3.3.6 Drainage Flows

30. In 1999, a total volume of approximately 39 km^3 of drainage water was generated within the Aral Sea Basin, at an average rate of about 5,100 m^3/ha. Details of the annual rates of generation, and average salinity levels in the drainage water, are presented for the two main basins in Table 11 and Table 12. Of the total volume, about 4 km^3 was recycled for irrigation, 18.5 km^3 was discharged back to the river system, and 16.7 km^3 was discharged to desert sinks.

31. Future drainage flows will be reduced by improvements to on-farm water management and infrastructure and to the operation of the supply system. International experience has shown that, with improved management, it should be possible to reduce drainage flow rates to about 3,000 to 4,000 m^3/ha.

Table 11: Drainage Flows in the Syr Darya Basin in 1999

Area/PZ	Area drained '000 ha	Average salinity of drainage water (g/l)	Volume of Drainage Water (million m^3)				Unit volume '000m^3/ha
			Discharged to rivers	to depressions	Reuse in irrigation	Total	
Upstream Locations							
Kyrgyzstan	460	1.2	800	-	-	800	1.7
Uzbekistan							
Andijan	280	1.7	1,200	-	100	1,300	4.6
Namangan	280	2.8	1,100	-	1,200	2,300	8.2
Ferghana	360	2.8	2,000	-	1,000	3,000	8.3
Tadjikistan	300**	2.1	1,800	-	400	2,200	7.3
Middle Reaches							
Uzbekistan							
Tashkent	390	2.1	2,200	-	300	2,500	6.4
Syr Darya	280	3.6	400	1,400	100	1,900	6.8
Djizak	300	4.4	-	1,100	100	1,200	4.0
Kazakhstan							
*Shymkent**	480	2.6	400	600	-	1,000	2.1
*Kyzyl-Orda**	290	3.4	600	600	-	1,200	4.1
Total	**3,420**		**10,500**	**3,700**	**3,200**	**17,400**	**5.1**
%			**60**	**21**	**19**	**100**	

* data 1990

** Assumed

Source: Jakubov, K., Usmanov A. RWG Report 'To Identify and Map Main Sources of Salt Generation', July 2001. Table 3.12.

Table 12: Drainage Flows in the Amu Darya Basin in 1999

Area/PZ	Area drained '000 ha	Average salinity (g/l)	Volume of Drainage Water (million m^3) Discharged to rivers	to depressions	Reused in irrigation	Total	Unit volume '000m^3/ha
Upstream Locations							
Tadjikistan	530	1.3	4,000	-	-	4,000	6.8
Uzbekistan							
Surkhandarya	320	2.2	600	-	500	1,100	3.4
Middle Reaches							
Uzbekistan							
Kashkadarya	490	7.1	800	1,500	-	2,300	4.7
Bukhara	340*	4.2	800	2,000	-	2,800	8.2
Turkmenistan							
Dashkovus	460	3.5	-	2,300	-	2,300	5.0
Lebab	320	2.3	1,500	300	-	1,800	5.6
Downstream							
Uzbekistan							
Khorezm	260	3.7	-	3,100	200	3,300	12.7
Karakalpakstan	500	4.2	300	1,900	-	2,200	4.4
Turkmenistan							
Akhalsk	480	9.2	-	500	-	500	1.0
Mari	470	5.0	-	1,400	-	1,400	7.0
Basin Total	**4,170**		**8,000**	**13,000**	**700**	**21,700**	**5.2**
%			**37**	**60**	**3**	**100**	

* data of 1990
Source: Jakubov K., Usmanov, A. RWG Report 'To Identify and Map Main Sources of Salt Generation', July 2001. Table 3.13.

32. The objective of drainage is to regulate watertable levels, to prevent salt accumulation processes and to enhance the productivity of irrigated lands. Not all irrigated areas that require drainage have the necessary infrastructure in place, with 5.3 million ha being supplied with drainage infrastructure out of a total of 5.7 million ha of irrigated lands which require it. Unit lengths of drainage infrastructure in the basin range from 0.3 to 19 m/ha for inter-farm and from 5.5 to 67 m/ha for on-farm network, depending on climatic zones, altitudes, relief of localities, purpose and design of irrigation system and other factors (Table 13). There is one common characteristic - insufficient O&M funding – and as a consequence the technical condition of the drains is generally unsatisfactory. Excessive weed growth is the main problem, together with slumping of the drain walls, especially in rice systems in downstream areas. According to data from the Tadjikistan NWG, from 27% to 53% of all drainage systems and associated structures are in an unsatisfactory condition. In Kyrgyzstan the figures are 17-32%. As a result, drainage flows are largely unregulated and in many cases are lost irretrievably. Of the 7,760 drainage wells existing throughout the Basin, only about 2,770 or 35% are currently working.

Table 13. Collector Drainage Network of the Aral Sea Basin, 2000

Country	Irrigated area ('000 ha)	Area requiring drainage ('000 ha)	Including			Length of the collector network (km)				
						Main, inter-farm		On-farm		
			Drained	Type		Total	m/ha	Total	m/ha	Incl. closed horizontal
				Horiz-ontal	Vert-ical					
UZB	4,266	3,160	2,924	2,523	401	31,353	8-19	106,440	10-67	38,300
KAZ	786	530	522	202	320	2,400	3.1	13,700	28	Pilot Plot
KYR	412	158	158	157	1	42	0.3	970	6.1	160
TUR	1,714	1,511	1,511	1505	6	8,989	5.2	25,263	15	6,346
TAD	718	364	364	323	41	2,213	6.4	9,279	32	3,817
Total for Basin	**7,896**	**5,724**	**5,479**	**4,710**	**769**	**44,997**		**155,652**		**48,623**

3.4 Electrical Energy Sector

3.4.1 Importance of Hydropower in Water Resource Planning

33. Approximately 37% of the electrical generation capacity in the Aral Sea Basin are provided by hydropower stations in Kyrgyzstan, Tadjikistan and, to a lesser extent, Uzbekistan. This, together with the fact that there is enormous potential for further hydropower development in the upstream countries, illustrates the importance of giving due consideration to hydropower in the planning, development and management of water resources.

3.4.2 Energy Use

34. Since 1990 there has been a decline in consumption of electricity in all five Central Asian Republics, although a slight recovery has taken place over the last couple of years. All countries went through a decline in consumption in the first half of the 1990s. From then on consumption stabilised in all countries except in South Kazakhstan, and at the end of the decade the consumption had increased slightly in both Uzbekistan and in Turkmenistan.

35. Generally, there is a close interrelation between GDP and energy consumption, although causal factors also include population growth and per capita consumption. Predictions of GDP are often difficult, and as an alternative future demands could be forecast by extrapolation of past trends. Two such forecasts estimate that by 2025 the annual electricity demand in Central Asia will increase by between 35 TWh and 78 TWh in one case and by 41 TWh in the other. These represent percentage increases of 37-82 % and 42% respectively. Past and predicted future energy use in the region is summarised in Table 14.

Table 14: Energy Use in Central Asia (TWh[1])

Year	Kazakhstan[2]	Kyrgyzstan	Tadjikistan	Turkmenistan	Uzbekistan	Total
1990	25.9	9.2	19.3	9.6	54.0	118.2
1995	14.7	10.9	15.4	8.3	46.1	95.6
2000	9.2	11.8	15.5	8.9	48.1	93.7
2010[3]	11.8	15.1	19.8	11.4	61.6	120
2025[3]	17.0	21.8	28.7	16.5	89.0	173

1. 1 TWh = 10^9 kWh
2. South Kazakhstan only
3. 2.5% annual growth rates assumed for all countries

3.4.3 Current and Future Generating Capacity

36. The number of existing power stations and current generating capacities in each country are summarised in Table 15. This shows a preponderance of hydro-stations in Kyrgyzstan and Tadjikistan and of thermal stations in the other three countries.

Table 15: Existing Thermal and Hydro Power Stations and Generating Capacity

Country	Type of PS	Capacity MW		Number of stations >50Mw
		Installed	Net	
S. Kazakhstan	TPS 1)	2,933	1,890	6
	HPS	525	241	2
Kyrgyzstan	TPS	673	614	2
	HPS	2,985	2,862	5
Tadjikistan	TPS 2)	297	224	2
	HPS	4,066	3,596	4
Turkmenistan	TPS	2,651	2,497	4
	HPS 3)			
Uzbekistan	TPS	9,873	8,065	8
	HPS	1,710	1,211	8
Subtotal	TPS	16,427	13,290	22
Subtotal	HPS	9,286	7,910	19
Central Asia		**25,713**	**21,200**	**41**

TPS= thermal power stations, HPS= hydro power station
1) Including Jambil but its actual production is low because of expensive, imported gas.
2) Actual used capacity is 27 MW lower because of imported, expensive gas.
3) Turkmenistan's hydropower capacity is insignificant

37. The electricity demand forecasts for 2025 suggest the need for net capacity increases of between 5,300-12,000 MW in one case and around 10,000 MW in the other. However, since some existing capacity will have to be decommissioned because of age, the actual new/replacement capacity required in this period is likely to be in the order of 12,000–18,000 MW (see Table 16). Potential new thermal and hydro power stations, and likely production costs based on a number of assumptions, are summarised in Table 17.

Table 16: Forecast of Required Electrical Generating Capacity

	2000 Net capacity	2025 Additional Net Capacity Requirement	
		Forecast (1)	Forecast (2)
Capacity (‘000 MW)	18.9	5.3 - 11.9	9.8
Capacity requirement (%)		28 - 63%	52%

(1) Power Transmission Modernisation Project in the Central Asia Region – ADB project TA 5960-RETA
(2) Extrapolation of 1996-2000 data

Table 17: Potential New Thermal and Hydro Power Stations

Country	Name of PS	Capacity (MW)	Capital cost (Mln US$)	Annual production TWh	Production costs (US cents per kWh)		
					2002	2010	2025
Thermal Power Stations							
KAZ	S-Kazakhstan (coal)	3,000	2,400	18,396	3.4	4.2	4.4
TUR	Mary a.o. (gas)	818	654	5,016	3	3.5	4.1
UZ	Talimarjan (gas)	3,600	2,880	22,075	3	3.5	4.1
	New TPS (gas)	1,500	1,200	9,198	3	3.5	4.1
Total		8,918	7,134	54,685			
Hydropower Stations							
KAZ	Small HPSs	960	1,056	4,205	2.8	2.8	2.8
KYR	Kambarata II	360	288	1,577	2.1	2.1	2.1
	Kambarata I	1,900	1,680	5,114	2.1	2.1	2.1
	Ala-Bukin	500	400	2,500	2.1	2.1	2.1
TAD	Rogun	3,600	1,260	15,768	1.1	1.1	1.1
	Sangtuda - 1	670	536	2,935	2.1	2.1	2.1
	Pyanj-Vakhsh tunnel	3,000	350	13,140	0.3	0.3	0.3
TUR	Small HPSs	350	280	1,533	2.8	2.8	2.8
UZ	Small HPSs	800	640	3,504	2.8	2.8	2.8
Total		12,140	6,090	50,275			

4. WATER RESOURCES

4.1 Surface Water Resources

38. The surface water resources of the Aral Sea basin, based on long-term records (1959-1999), are summarised in Table 18. They indicate a total long-term annual flow of 116 km^3.

Table 18. Surface Water Resources of the Aral Sea Basin (Long Term Average Annual Flow) (km^3/year)

Country	River Basin		Total for Aral Sea Basin	
	Syr Darya	Amu Darya	km^3	%
Kazakhstan	2.5	-	2.5	2.2
Kyrgyzstan	27.5	1.7	29.2	25.2
Tadjikistan	1.0	58.7	59.7	51.5
Turkmenistan	-	1.4	1.4	1.2
Uzbekistan	5.6	6.8	12.4	10.6
Afghanistan and Iran	-	10.8	10.8	9.3
Total for the Aral Sea Basin	36.6	79.4	116.0	100.0

Source: SANIGMI

39. In recent years the average volume of water passing through to the Aral Sea has been approximately 12 km^3 per year. Thus the volume used for all purposes in the Basin, including evaporative losses, accessions to the groundwater, and losses in desert sinks, amounted to 102 km^3 per year. Allowing also for the reuse of water and return flows to the main river systems, the total diversions amounted to about 120 km^3.

40. With respect to future changes in water availability as a result of climate change, studies show that there has been a slight increase in average flow from 1975 onwards. According to a report on climate change by the Hydrometeorological Service of Uzbekistan, there is a trend to rising air temperatures in both summer and winter, transient snow reserves in the upper watersheds are being reduced, and glaciers are becoming degraded. Looking to the future, several studies using different climatic models suggest that:

- In the short to medium term (next 10 – 20 years) glaciers will melt further, and the annual flows will increase. However, this effect will lessen with time.
- In the long term (after more than about 20 years) the melting of glaciers will be halted, and what remains will generate less flow than at present. On the other hand, an increase in mountain rainfall is likely to partly offset this. However, since rainfall is far more erratic than glacial flow, it is expected that the resulting monthly flows will show considerably more variability.

41. The overall conclusion is that, in the short term, the main change will be a slight increase in flow with little or no change in variability (including wet and dry periods), while over the long term (by 2025) there will probably be less flow than now and greater variability.

4.2 Groundwater Resources

42. According to hydrogeological estimates the underground water sources in the Aral Sea Basin have a total annual potential yield of about 43 km^3, of which 25 km^3 is in the Amu Darya basin and 18 km^3 in the Syr Darya basin. The distribution between the five countries of the available groundwater reserves, and the current usage (1999) of extracted water, is shown in Table 19.

Table 19: Groundwater Availability and Use in Year 1999 by Country (km^3/year)

Country	Regional Resources	Approved for Utilisation	Actually used in 1999	Purpose			
				Drinking Water Supply	Industrial	Irrigation	Vertical Drainage
Kazakhstan	1.85	1.27	0.29	0.20	0.08	0	0
Kyrgyzstan	1.60	0.63	0.24	0.04	0.06	0.01	0
Tadjikistan	18.23	6.02	2.29	0.48	0.20	1.59	0
Turkmenistan	3.36	1.22	0.46	0.21	0.04	0.15	0.06
Uzbekistan	18.45	7.80	7.75	3.37	0.71	2.16	1.35
Total for the Aral Sea Basin	**43.49**	**16.94**	**11.04**	**4.32**	**1.09**	**4.04**	**1.41**

43. It can be seen that groundwater is a significant source of irrigation water only in Uzbekistan. The total of about 4 km^3 per year used for irrigation in the Aral Sea Basin was small compared with the 120 km^3 diverted annually from surface sources. Groundwater is usually more saline than surface water, and its use involves considerably higher costs for pumping and pump and bore maintenance. It appears therefore that, although there is some potential for greater use of groundwater for irrigation, it is unlikely to provide a large part of the total irrigation usage.

4.3 Effects of Water Management Improvements

44. An indication of the water use efficiencies that currently apply throughout the Aral Sea Basin is provided by the data in Table 20, which shows the supply system and in-field efficiencies in several areas that are representative of conditions throughout the Basin.

Table 20: Current Water Use Efficiencies in Representative Areas

Zones	Supply System Efficiency (1)	In-field Application Efficiency (2)	Overall Efficiency
Upper reaches			
Namangan/Uzbekistan	63	62	39
Tadjikistan	62	64	40
Old/ middle-plain zones			
CHAKIR/Kazakhstan	63	70	44
Fergana/Uzbekistan	55	73	40
Mary/Turkmenistan	58	70	41
Osh/Kyrgyzstan	59	70	41
New/middle-plain zones			
Hunger steppe/Kazakhstan	63	70	44
Syr Darya/Uzbekistan	73	71	52
Old lower reaches			
Khorezm/Uzbekistan	52	65	34
Dashoguz/Turkmenistan	53	70	37
New lower reaches			
Karakalpakstan/Uzbekistan	48	70	34

Source: NWG Reports

1.Supply system efficiency is ratio between volumes of delivered to the field and diverted from the source river.

2.In-field efficiency is ratio between the volumes used for crop growth and delivered to the field.

45. The figures show that in many areas approximately half of the water diverted from source rivers for irrigation is not delivered to the fields. A small proportion is lost by evaporation, but most is lost by seepage main, inter-farm and on-farm canal systems. Substantial operational losses also occur, in the form of overflows (spills) of water from main, inter-farm and farm canals into the drainage system. Much of this water is reused further downstream, but a substantial proportion is diverted to desert sinks and lost by evaporation and seepage. The substantially higher efficiency of the supply system in the new mid-plains areas probably reflects the higher proportion of lined channels and the relatively low permeability of the soils, and possibly also a more efficient management and control system.

46. The studies indicate that, averaged over the whole Basin, main canal seepage amounts to about 1,600 m^3/ha/year and farm canal seepage to 2,900 m^3/ha/year, which for the whole Basin represent total volumes of 13 km^3 and 23 km^3 per year respectively. In-field seepage amounts to an estimated 3,300 m^3/ha/year, or 26 km^3 per year, although much of this is used by crops in the form of subsurface irrigation water.

47. Reductions in in-field seepage and operational losses will be achieved mainly by better on-farm water management and irrigation practices, which will involve expenditures (average basin wide capital investment: US$ 1,300/ha and average yearly O&M costs: US$ 50/ha/year) on the refurbishment of existing measurement and control structures, the provision of new ones, and training of operational staff in water-saving practices and various improvements of irrigation practices. The various measures and combinations of measures were evaluated during Phase III for various farm types in various regions. The results, including cost-benefit analyses, were presented in Regional

Report 2, Supporting Volume, particularly in Section 8.10. The savings from a reduction of 50% in in-field seepage, which should be achievable without difficulty, would provide an additional 12 km^3 per year for other use.

48. Approximately 60% of the drainage water generated in the Amu Darya basin (that is not recycled from the drains for irrigation) is discharged to desert sinks, while in the Syr Darya basin the proportion is 25%, excluding spills to Lake Arnasay from Chardara reservoir. It is considered possible to reduce drainage flows by about 40% with improved water management, achieved principally by improved operation of the main supply system and of the on-farm distribution systems to eliminate direct spills of surface water into drains. Studies by the Regional Working Group estimate that a reduction of this size in drainage flows would reduce the total losses in the Aral Sea Basin by about 5 km^3 per year.

49. Thus it is considered that improved water management has the enormous potential to reduce losses by 17 km^3 per year, as a result making available that volume for higher agricultural production and ecological and sanitary purposes in the Aral Sea Basin.

5. SANITARY AND ECOLOGICAL WATER REQUIREMENTS OF RIVERS, WETLANDS AND THE ARAL SEA

5.1 Demand Components

50. There are three main components to the ecological water requirements of the Basin: (i) those of the lower reaches of the two rivers, (ii) those of their associated water bodies and wetlands, and (iii) those of the Aral Sea itself. The Aral Sea in the year 2002 consisted of three segments: an isolated part in the north – the Northern Aral Sea, fed by the Syr Darya - and two major water bodies – the Western Aral Sea and the Eastern Aral Sea (together referred to as the Larger Aral Sea) fed by the Amu Darya. The Western Aral Sea and the Eastern Aral Sea are about to disconnect from each other completely.

5.2 Values of Wetlands and the Aral Sea

51. The lake systems and wetlands in the deltas of the Amu Darya and Syr Darya are important to the local people as sources of fish, reeds as fodder and construction material, and muskrats for fur, and the surrounding territories are used as pastures for livestock. The wetlands and lakes in the deltas also replenish the groundwater, which is often an essential source for domestic water supply in dry years.

52. Several wetlands and lakes (e.g. Sudoche wetland, Kamishlibash lake system) are areas of international importance for waterfowl. They are important nutrient sources and rest areas for migrant birds, being located along important passage routes, and provide permanent habitat and nesting places for many indigenous birds. The delta wetlands also provide spawning areas for many fish species, and will be the main resource from which to replenish the Aral Sea with its former fish species.

53. The delta areas are also of great importance for mammals, although out of 45 species that earlier inhabited the marshlands of the Amu Darya delta only 34 now survive. The presence of the water bodies in the deltas, with their high evaporation, softens the local climate, reducing the heat in summer and delaying the cold in winter.

54. The Aral Sea used to have huge fish resources of commercial importance. Nowadays only the northern segment of the Aral Sea has a salinity level that some fish species (such as flounder) can survive in. With adequate regular water inflows a number of other species such as bream, sazan, vobla, and pike perch could become re-established in the Northern and Western Aral Seas. However, there is unlikely to be any chance of re-establishing the previous recreational/resort use of the Sea and its immediate surrounds.

5.3 Salinity Criteria

55. In regard to the impacts of salinity, the ecological balance of inland waters starts to become affected when concentrations exceed 11 g/l, because above that level the growth rates of various fish species start to slow. At 14 g/l fish reproduction becomes a major problem, while above 18-20 g/l only some species (e.g. flounder) manage to survive. Thus the salinity levels in wetlands, reservoirs and the Aral Sea desirably should be less than 5 g/l, and should definitely remain below 11 g/l to guarantee ecological sustainability (especially with respect to fresh water species).

56. From the domestic water supply viewpoint, a salinity level of 1.0 g/l is the desirable limit, based on aesthetic (mainly taste) considerations, and is an appropriate criterion for the lower reaches of the two rivers in view of their role as the main source of domestic water for the population in the delta areas.

57. The water quality standards of the five States, as well as a number of international standards, are presented in Appendix 2.

5.4 Current Situation

58. The inflow to the Aral Sea varies considerably from year to year, depending mainly on conditions in the catchments. The average volume of Amu Darya water reaching the Larger Aral Sea per year is about 8.2 km^3 (1981-1997), ranging from 0.4 km^3 in dry years to up to 23 km^3 in wet years. The average volume of Syr Darya water discharged to the Northern Aral Sea is about 3.6 km^3 per year (1981-1995) ranging from 0.5 km^3 in dry years up to 10 km^3 in wet years. The average salinity level in the lower reaches of the two rivers is currently approximately 1.1 g/l in both cases. The salinity of the Larger Aral Sea in 2002 is over 60 g/l, while the Northern Aral Sea is at about 13 g/l and therefore at the limit which creates the threat for current biodiversity of these parts of the Sea.

5.5 Estimation of Environmental Flow Requirements

59. According to the flow schemes for the Amu Darya developed under Component E of WEMP, a minimum flow of about 6 km^3 is required annually on average for environmental purposes in the lower reaches. This includes 3.2 km^3 for sanitary flow (corresponding to 100 m^3/s) to maintain the quality of the river water and control pollution, 1.0 km^3 to safeguard fish health in lakes and fish ponds, and 1.5 km^3 for other ecological purposes such as maintaining wetlands.

60. The flow schemes developed for the Syr Darya indicate the need for a minimum average annual flow of about 8 km^3 in the lower reaches of that river. This includes 2.9 km^3 for sanitary flow purposes (corresponding to 50 m^3/s), 2.1 km^3 for ecological purposes such as maintaining wetlands, 1.3 km^3 to safeguard fish health, and an allowance for other purposes. In dry years, a sanitary flow of 50 m^3/s is considered acceptable.

61. The water requirements for sanitary purposes, wetlands and the Aral Sea have been investigated over the past years in various projects and studies. The flow requirements and volumes needed vary between the sources, but in general the variations are marginal. Currently the RWG is reviewing the various assumptions underlying each estimate in order to clarify the issue and to propose requirements that will be acceptable to all parties concerned.

62. In regard to the Northern Aral Sea, studies by the Regional and National Working Groups have shown that salinity levels of 11 g/l or less can be maintained with an average annual inflow from the Syr Darya of about 5 km^3.

63. With respect to the other segments of the Sea, the Academy of Science of Uzbekistan has developed a plan that would save the Western Aral Sea, while the inflow to the Eastern Aral Sea would be reduced gradually and this part would eventually dry up. This plan has been approved by the Uzbekistan State Committee for the Protection

of Nature. It assumes that the Western and Eastern Aral Seas will remain as separate entities, and involves diversion of sufficient flow into the Western Aral Sea from the Amu Darya to eventually reduce the salinity to 11 g/l and maintain it at or below that level. The flushing flows passing through both the Northern and Western Aral Seas would overflow to the Eastern Aral Sea, which would then become a saline sink. Studies by the Regional Working Group have shown that, with an inflow of 15 km^3 per year to the Western Aral Sea, the salinity level would fall to 11 g/l in about 30 years. With an inflow of 12 km^3 per year that limit would be reached in about 45 years, and with 9 km^3 per year it would take more than 100 years.

64. On the basis of the above, the minimum average flow requirements in the lower reaches of the rivers for sanitary and ecological purposes would amount to 18 km^3 per year for the Amu Darya and 11.5 km3 for the Syr Darya, totalling 29.5 km^3 per year in all. This may be compared with the total volume passing through to the Aral Sea under current conditions of about 12 km^3 per year, and would require an increase of about 18 km^3 per year.

65. It is clear from the current NWG studies that a volume of that magnitude cannot be expected to become available for ecological purposes if the currently prevailing economic and social objectives of the national governments are to be met.

6. NATIONAL WATER AND SALT MANAGEMENT PLANS

6.1 Introduction

66. In Phase IV of the WEMP A1 project, the NWGs developed National water and salt management plans following general guidelines established by the Regional Working Group. These management plans were developed in close association with the relevant government agencies of the countries concerned, such as Ministries of Agriculture and Water Resources, Nature Protection, Energy, etcetera. Generally the plans follow closely the relevant government development policies for the short to medium term. The plans have received preliminary endorsement from the relevant government agencies. The plans are presented in detail in the National Reports No. 1, and the key aspects are summarised in the following sections. An overview of the plans is then presented, which provides an assessment of their practicability from a regional viewpoint.

67. The projected values for economic indicators and agricultural productivity adopted by the various National Working Group reports are presented in Chapter 2. Those values generally have been derived assuming high growth scenarios. The national plans are generally based on the high growth 'Revitalisation' or 'Composite' scenarios.

6.2 Kazakhstan

68. The total surface water resources of the Kazakh segment of the Aral Sea Basin, comprising the outflow to the Syr Darya from Chardara Reservoir, Arys River flows and drainage return flows, amount to 18.06 km^3 in an average year. Groundwater resources amount to about 0.8 km^3 per year. Currently agriculture consumes about 95% of the available resources. The water management plan is therefore directed towards increasing the economic efficiency of agriculture and reducing water consumption to provide water for rehabilitation of the Syr Darya delta and maintenance of an adequate level in the Northern Aral Sea.

69. The population of the Kazakh segment of the Aral Sea basin is projected to rise from 2.6 million in 2000 up to 3.1 million in 2010 and 4.8 million in 2025. The reserves of arable land are virtually exhausted and only a small increase in irrigated area is proposed, from 790,000 ha in 2000 to 815,000 ha in 2025. It is envisaged that the water needed for the additional irrigation areas, and to meet the ecological requirements of the delta area and the Aral Sea, will be obtained by improvements to water management practices and to the technical condition of the supply system. An increase in overall irrigation efficiency from the present 45% to about 67% in 2025 is assumed as a result. The assumption is that the food needs of the larger population will be provided by increased agricultural productivity resulting from improvements or increases in: fertiliser use, disease and weed control, new crops and plant varieties, crop rotations, changes to cropping patterns, and other agronomic measures. The plan assumes that overall agricultural productivity can be increased by 50-60% in the period up to 2025 by these measures

70. Investment in irrigation is estimated at $US1.3 billion in the period 2001- 2010, and a further $US1.3 billion up to 2025. The plan envisages increasing investment by

the private sector in irrigation projects, with eventually about 25% coming from this source, 50% from state sources and the remainder in the form of international loans.

6.3 Kyrgyzstan

71. The population in the Kyrgyz segment of the Aral Sea Basin is currently about 2.2 million. It is projected in the water management plan that this will increase to 2.7 million by 2010, and 3.5 million by 2025. In order to provide the increasing population with food, and industry with raw materials, the plan assumes that an additional 20,000 ha of irrigated land will be brought into production by the year 2010 and a further 56,000 ha by 2025.

72. The annual water requirements of the new lands by the year 2010 are estimated at 0.21 km^3, rising to 0.6 km^3 by 2025. It is envisaged that a further 0.58 km^3 per year will be required to increase water supplies to existing irrigated lands up to 1990 levels with a view to increasing crop productivity by 10 % by 2010 and 15 % by 2025. In total, by 2025 the water intake volume in the Kyrgyz part of the Aral Sea Basin, calculated on this basis, will amount to 6.0 km^3.

73. Investments required in the irrigation sector are estimated at about $US 424 million for infrastructure rehabilitation and new land development, and $US 29 million for on-farm works. In the 2001-2005 period, when the economy of water users is still weak, it is envisaged that the state share will be 60-80% of the total amount. The assumption is that, as the water users' economy becomes stronger, their share will increase while the state's share will decrease and in the long-term fall to zero.

74. As for hydrogeneration facilities, the Kyrgyz Government is seeking investors for the construction of Kambarata 1 and Kambarata 2 stations. Negotiations are ongoing between Kazakhstan, Uzbekistan and Kyrgyzstan regarding joint funding of the construction. The emphasis will be transferred from state investments to direct foreign investments, because they produce new capital, technologies and modern management practices.

75. The following are envisaged in the medium-term plan with regard to issues of interstate water use:

- Conclusion of an agreement with neighbouring countries on sharing the operating and maintenance costs of water facilities of interstate use located in Kyrgyzstan.
- Development of a method of sharing these costs and damages between the water user countries.

6.4 Tadjikistan

76. Tadjikistan has considerable water resources which are largely under-utilised, with only 14 km^3 of the total 60 km^3 of river flow originating annually on average in its territory currently being used. It also contains large areas of land suitable for irrigation, and the Tadjikistan government has adopted a concept of rational use and conservation of water resources that envisages the full development of these lands in the future. As set out in Table 1, the national population is projected to grow to 7.3 million by 2010 and 9.0 million by 2025.

77. To provide the necessary foodstuffs and agricultural raw materials, the plan envisages that it would be necessary to increase the irrigated area from 718,300 ha in 2000 to 1,060,000 ha in 2010 and 1,200,000 ha in 2025, with about 60% of the development in the Amu Darya catchment and the remainder in the Zerafshan catchment. The development will necessitate increases in annual water use from the current level of 14.1 km^3 to 15.5 km^3 by 2010 and to 18.1 km^3 by 2025. It is envisaged that the total water use in the country in the future will amount to 22 km^3 per year. The poor technical condition of most of the irrigation systems is seen as the cause of substantial water losses, and the plan promotes a number of measures to improve the situation, including economic incentives for water saving, modernisation of the irrigation systems, implementation of advanced irrigation techniques and technology, and accelerated establishment of water users associations.

78. The plan suggests that hydropower will become increasingly important with time. It assumes that Rogun and Sangtudin hydrosystems will be completed by 2025, leading to a substantial increase in the regulation of the flows in the Vaksh River. The plan estimates that the annual production from the Vaksh Cascade will increase from about 15 TWh to 28 TWh by 2025, with the amount in the vegetation period increasing from the current 10.0 TWh to 14.2 TWh. Annual energy production from the Nurek system is expected to remain constant at about 11.3 TWh, decreasing in the vegetation season from the current level of 7.4 TWh to 5.6 TWh. Under these conditions the reservoir releases will be 20.4 km^3 per year, decreasing in the vegetation season from the current 13.4 km^3 to 10.2 km^3 by 2025.

79. Issues raised in the plan include:

- The need for interstate cooperation in the use of energy, particularly for the downstream countries to increase the use of energy generated in the vegetation period by releases for irrigation. In the period 1990-2000 on average 1.6 TWh per year of energy that could have been generated by releases for irrigation was not utilised.
- The suggestion that the dealings between economic entities in the water and energy sectors, including compensation payments, should be carried out on an economic basis.
- The suggestion that payment should be made for the accumulation and supply of water in the vegetation period, taking into account both the capital costs and the operating and maintenance costs of the storage and supply works.

6.5 Turkmenistan

80. The surface water resources of Turkmenistan, comprising 22 km^3 per year (this is a minimum value and refers to a “90% dry year” situation) diverted from the Amu Darya and the remainder originating from the Murgab, Tedjen and minor rivers, amount to 23.4 km^3 in an average year. Currently, groundwater resources amount to 1.2 km^3 per year, and these are assumed to rise to 3.2 km^3 per year by 2025. The national population is projected to grow to 8.6 million by 2010 and 13.1 million by 2025.

81. To provide adequate food the plan envisages an increase in the irrigated area from the current 1.7 million ha to 2.2 million ha in 2010 and 2.8 million ha in 2025. The

assumed cropping pattern in 2025 includes about 900,000 ha of wheat and 800,000 ha of cotton. The plan envisages that total water use will not increase significantly, and that the supply of water to the additional irrigated areas will be achieved by improvements to the efficiency of the main supply system and to on-farm water management. The overall irrigation efficiency (including field efficiency) is assumed to increase from the current 0.45 to 0.65 by 2025.

82. The projected investments in the irrigation sector up to 2025, including the cost of the Turkmen Lake of the Golden Era project, total $US9 billion, distributed over time as follows:

Period	Investment ($US billion)
2001-05	3.6
2006-10	3.0
2011-25	2.4
Total	9.0

83. Virtually all electrical energy is generated in thermal power stations in Turkmenistan, and there are no significant water-energy issues.

6.6 Uzbekistan

84. The national water management plan for Uzbekistan is based on the principle of self-sufficiency in food production (wheat and rice, potatoes, fruit and vegetables in the long term, and partial self-sufficiency of industrial needs in feed grain), with a moderate growth scenario in the medium term (up to 2010) and a high growth scenario from then on. Key elements of the plan involve productivity improvements in irrigated agriculture through better technology, changes to crop patterns, and through transformation to a market economy.

85. It is envisaged in the most optimistic scenario that the irrigated area will increase from the present 4,260,000 ha to 4,360,000 ha by 2010 and to 6,440,000 ha by 2025. The area sown to cotton is assumed to drop slightly from the current 1,510,000 ha to 1,450,000 ha in 2010 and then remain constant. The plan envisages a 50% increase in the area of wheat and other grain crops between 2010 and 2025 and a 230% increase in the area of fodder crops. This includes development of 200,000 ha in flood lands in the Amu Darya delta for livestock breeding.

86. The plan assumes that substantial improvements in irrigation efficiency will be achieved through organisational, technical and institutional measures, to provide the necessary water for the new developments. The assumed values for efficiency are shown in Table 21. They represent reductions of 6% in the volume of irrigation water applied per hectare by 2010, and of 28% by 2025.

Table 21. Current and Assumed Future Irrigation Efficiencies in Uzbekistan

	Present	2025
Off-farm and on-farm channel system	0.58	0.79
In-field	0.68	0.88
Total	0.39	0.69

Source: Uzbekistan NWG report

87. The plan includes an annual allowance of 1.0-1.2 km^3 to maintain the Arnasay system, and 3 km^3 for the delta lakes and the Aral Sea. As shown in Table 22, the water demands for all purposes are projected to increase from 66 km^3 per year in 2010 to 72 km^3 per year by 2025, which is within the limits of the corrected complex schemes.

Table 22: Total Planned Water Demand – Uzbekistan (km^3)

Year	Basin	Irrigation	Other Uses	Total
2010	Syr Darya	21.0	6.5	27.4
	Amu Darya	33.4	5.0	38.4
	Total	54.4	11.4	65.8
2025	Syr Darya	20.3	7.2	27.4
	Amu Darya	38.7	6.3	45.0
	Total	59.0	13.4	72.4

Source: Uzbekistan NWG report

88. The plan envisages a transfer of excess water from the Chirchik basin to the Hunger Steppe, and creation of a reservoir in the Arnasay depression and two reservoirs on the fringes of the Ferghana Valley, which will allow greater flexibility in the operating regime of Toktogul reservoir. The plan also anticipates that Tadjikistan will complete the construction of the Rogun dam on the Vaksh River in Tadjikistan, enabling better control of floods and better regulation of irrigation flows in the Amu Darya Basin.

89. The construction of more hydropower generation capacity is proposed by 2010, including new stations on the Pskem and Akhangaran Rivers, increasing the utilisation of the national hydro-power potential from the current 11.3% to 13.5%. Subsequent developments are proposed to take the utilisation level to about 25% by 2025.

90. The proposed investment in the period to 2025 amounts to a total of $US 32 billion, the bulk of it in the long term as shown by the proposed distribution below:

Period	Investment ($US billion)
2001-05	1.2
2006-10	1.5
2011-25	29.1
Total	31.8

91. Sources of finance are seen to include national government budget allocations, international financial organisations, and mobilisation of private domestic funds.

6.7 Overview of National Plans

6.7.1 Water Availability

92. The plans for Kazakhstan and Turkmenistan assume that there will be no significant additional requirement for irrigation water, and that the requirements of the additional lands will be met by improvements in irrigation efficiency.

93. With their current plan, Tadjikistan envisages an increase in water use of 4.0 km^3 by 2025. About 2.4 km^3 of this would represent a direct deduction from the Amu Darya flow shared between Uzbekistan and Turkmenistan, and this would eventually lead to a decrease in the volume available to each of those countries of 1.2 km^3. The other 1.6 km^3 is planned to be taken from the Zerafshan catchment, and this would also represent a decrease in the Uzbekistan resource.

94. The reduction of 1.2 km^3 represents about 5% of the Turkmenistan allocation, and is probably within the margin of accuracy of the assumptions used in developing the national plan. The reduction in Uzbekistan available resource would amount to 9% of its allocation for the Amu Darya basin, and is of more significance. The impacts of these reductions are evaluated in more detail in Chapter 6.

6.7.2 Water Productivity Improvements

95. The term irrigation efficiency is a loose one that can apply to the main, inter-farm and on-farm supply systems, in-field application, or combinations of these. Where efficiency values are stated in the national plans, it is not always clear which of these is referred to. The plans all assume significant increases in irrigation efficiency in the future, through both technical measures and the wide introduction of Water User Associations. International experience suggests that some of the values may be optimistic. Thus water savings may be overstated in some cases.

96. Apart from technical measures to improve water productivity, much gain can be expected from land restructuring and privatisation of water management through the widespread introduction of Water User Associations, which will provide an important instrument for improving on-farm water use and reduce losses.

6.7.3 Environmental Impacts

97. The conflict between the requirements of irrigation and domestic and industrial water supply in the Basin on the one hand, and the need for inflow to the Aral Sea and delta wetlands to maintain environmental values on the other, has been evident for many years. As shown in Section 5.5, it would be desirable for ecological reasons to pass a total of about 30 km^3 per year of water through to the Aral Sea or its delta wetlands. This could be termed the ‘demand side’ of the equation.

98. On the ‘supply side’ of the equation, the volume currently passed through to the Sea and its wetlands amounts on average to about 12 km^3 per year. It is difficult to determine the total volume of water allocated by the five countries for ecological purposes, but the national water management plans do not appear to allow for any significant increases in individual national allocations. In fact, since the estimates of available water are optimistically high, as noted above, there is likely to be pressure to decrease the ecological requirements to enable social and economic objectives to be

achieved. The difference between supply and demand is too great for there to be any realistic hope of the projected demands being met, and it is concluded that the objective of saving the Western Aral Sea and restoring biodiversity there over 30 years is not a feasible one.

99. Removal of the 15 km^3 per year allocation for the Western Aral Sea would leave a target average minimum flow of 19 km^3 per year, which represents a 7 km^3 per year increase on current levels. This is considered the maximum that could realistically be expected in the short to medium term, although, as pointed out in Section 4.3, water management improvements could yield substantially more in the long term.

6.7.4 Optimum Use of Existing Irrigation Development

100. A major conclusion of the Regional Working Group's studies is that priority should be given to making optimum use of existing irrigation developments before consideration is given to the development of new irrigation projects. The reason is that this approach is likely to give a substantially better return on scarce capital because:

- The development of new lands will require expenditure, not only on land development and irrigation and drainage infrastructure, but also the necessary plant and machinery and associated workshops, and all other infrastructure such as roads, electricity, water and gas supplies, housing, and social facilities such as schools, hospitals, police stations, etc.
- New developments are likely to be undertaken on marginal lands, because generally the best land for irrigation, and the least costly to supply with water, has already been developed. Thus development costs are likely to be relatively high, crop yields are likely to be low, and there will be a high potential for problems such as salinization, requiring additional capital to remedy.

101. Large scale development of new lands for irrigation, including new main supply systems and the necessary services infrastructure, amounts to about $US6,000-7,000 per hectare. The development of new irrigation areas by extension of existing areas may be possible at lower cost by making use of the existing supply infrastructure, but nevertheless, the costs are still likely to amount to several thousand dollars per hectare. As against that, trials have shown that laser land levelling of fields increased the cotton yields on average by about 40%, and reduced water use by about 30%, at a cost of about $500/ha. Other measures, such as improving agricultural and irrigation practices, rehabilitation of the supply and drainage systems, etc., have also been shown to have high returns. It is clearly much more economic to obtain a 40% increase in net returns by a measure costing 10% of the cost of the alternative of new development. The implication is that, where capital is scarce (which, as shown in Section 6.7.7 is likely to be the case in all Central Asian countries) it would be far more economic to substantially improve irrigation on existing areas before considering any large-scale expansion of the irrigated area.

102. However, new lands development may have significant social effects in rural areas as the population increases. For example, 1,000 ha of new land under cotton will provide employment for about 400 people, providing annual incomes to the farmers of about $150/ha and supporting up to 1,500 people.

6.7.5 Concentration on Physical and Financial Aspects

103. In general, all national plans address adequately the physical requirements of the water and energy infrastructure, and the necessary funding. However, little or no attention appears to be given to non-physical measures. The greatest challenge in the agricultural sector is that of changing the attitudes of the people involved, the desired outcome being increased efficiency, based on a different outlook and greater knowledge. It is the way irrigated agriculture in Central Asia must develop eventually to remain viable in the developing global economy.

104. As described in previous reports, considerable education and training of farmers will be necessary if improved water management, with or without the use of new water-saving technologies, is to be achieved. This will be the case also in regard to agronomic improvement, and a package is proposed in Regional Report 2 that includes technical assistance in the first two years, and the provision of new equipment, training of specialists, and execution of field surveys, all on an on-going basis. The estimated costs of these measures are relatively low and will be affordable in most budgets, and the returns should be high and immediate. Thus they should be the first measures to be undertaken in any plan.

105. It is considered that the national management plans would be greatly enhanced if they acknowledged the importance of these aspects and that they have the highest priority. It is suggested that they should be given prominence in the NWG reports, and that specific funding allocations be shown in the budgets.

6.7.6 Prioritisation of Measures and Development Works

106. Most National Working Groups did not indicate the use of cost/benefit analysis in the preparation of their draft National Plans. The NWG of Uzbekistan provided outcomes of cost/benefit analyses of investment measures, but these analyses were not conducted according to international standards and methods. NPVs, IRRs, and BCRs were not calculated, and economic prices of products and resources were not used.

107. In view of the likely shortage of funds necessary to fully accomplish the proposed works programs, there would be considerable benefit in prioritising the various measures to ensure that the most important are implemented first. This would best be achieved by economic analysis of the costs and benefits, followed by assessment of social and environmental aspects.

108. Economic analyses of various on-farm measures by the Regional Working Group are described in Regional Report 2. The results are available to the NWG to assist in the prioritisation. Economic cost/benefit analyses of the rehabilitation of main and inter-farm canals and associated hydraulic structures are described in Appendix 3. The most profitable on-farm measures (with IRRs in the range 18% to 40%) include: improvements to traditional irrigation practices, laser land levelling, and better in-field and farm drainage on lands with significant salinization. The rehabilitation of main and inter-farm canals is also shown to be economically profitable.

6.7.7 Funding Practicability

109. In all Central Asian countries there is a vast backlog of expenditure on the rehabilitation, refurbishment and augmentation of all parts of the national infrastructure.

There is also a shortage, very severe in the case of some countries, of available funds to redress this backlog, and the capacity of most countries to generate the necessary funds is limited. The economic potential for the countries to increase or sustain their current domestic investments will depend on movements in the following main macroeconomic indicators: (i) GDP growth, (ii) consumption and savings, (iii) general government balance, (iv) balance of payments, and (v) external debt and debt-service ratios. The water resources sector will have to compete for the scarce funds with other sectors. It is considered essential that the strategies and plans be realistic and financially practicable in terms of the proposed expenditures, and to reflect this scarcity of funds.

110. The future investment capacities in each country have been assessed based on the aggregate analysis of these macroeconomic characteristics, using statistics and data from the World Bank and the International Monetary Fund. From the results of the analyses, it appears that in all the countries apart from Kazakhstan the macroeconomic situation is such that, to varying extents, it would be difficult to achieve the projected investments in the national plans produced by the NWGs. In particular, the estimates of Tadjikistan may be too optimistic, in view of the macroeconomic realities of extensive external debt and limited domestic investment potential. The current low growth rate in Uzbekistan makes the projected investments in that country quite problematic. Kyrgyzstan has now virtually exhausted its capacity to increase capital flows from official external resources, which are the main financing source for public investments at the moment. Overall, the limited investment capacities of the various countries will restrain water-related developments in the region, probably leading to prolongation of the implementation phases.

6.7.8 Analysis of Draft National Plans in the Regional Context

111. The potential development scenarios presented by the National Working Groups in their draft national plans sketch a picture for the future of what the Groups envisage as being possible when sufficient funds are available. All plans foresee measures to improve water productivity through rehabilitation and reconstruction of main and inter-farm supply infrastructure, and improvements to on-farm water management. In addition, the plans of Tadjikistan, Turkmenistan and Uzbekistan envisage the potential development of new areas of irrigation.

112. A key characteristic of all plans is that they assume much higher water productivity in the long term as a result of the investments, with an assumed increase in the efficiency of the overall systems from 40% to 65% over a 25-year period. In general terms, it is assumed that cotton production would be more or less stabilised, while there would be a substantial increase in cereal production and fodder crops i.e. there would be a change in emphasis from high value to low value crops

113. The Regional Working Group has undertaken analyses of the water and salt balance conditions that would prevail in the Aral Sea Basin in the future under the situations described in the national plans. These are described in Appendix 3. The overall conclusion of the studies is that, if the national plans are realised as presented, the overall impact on the water balance will be marginally positive, and very positive on the salt balance in the Planning Zones. However, full realisation of the plans is likely to require more time than envisaged, because enormous amounts of investment capital will

have to be mobilised, and even then the efficiencies aimed at are very high by international standards.

6.8 Enhancement of National Plans

114. Ways in which the national plans could be enhanced include:

- Adoption of consistent population growth rates as a basis for all plans, using the latest UN data and projections, and recalculation of the main dependent factors such as food requirements, water demands and irrigation areas.
- Acknowledgement of the importance and high priority of non-physical measures such as education and training and public participation and public awareness raising, and specific inclusion of them in the programs,
- Clarification of assumptions regarding irrigation efficiency, review of the assumed future values in the light of international experience, and reassessment as necessary of available water resources and consequent development programs,
- Assessment of the possible funds available for rehabilitation and new capital works, taking into account the various economic indicators listed in Section 3.2 and the fact that other sectors of the economies will be competing for funds, and if necessary revision of the development program,
- Prioritisation of proposed measures,
- Inclusion of clear statements in each national report on the volumes of the total national resource allocated to the Aral Sea and associated wetlands and other water bodies at the various stages.

7. WATER AND SALT BALANCES AND THEIR IMPLICATIONS FOR NATIONAL AND REGIONAL PLANNING

7.1 Objectives

115. This chapter presents short and long-term water and salt balances for the various planning zones and for the two river basins. They are considered in terms of various water supply and demand scenarios under different assumptions regarding: river salinity and flow targets, allocations to rivers, wetlands and the Aral Sea shore, and alternative development scenarios of the irrigation sector (ToR para. 117).

116. Analysis of water and salt balances is needed in order to test whether sustainable resource management can be achieved – at the national and the regional (basin) level, under various conditions and assumptions relating to:

- The various irrigation sector development perspectives,
- The potential operation regimes of major water storage reservoirs,
- The hydrological conditions,
- The requirements of the rivers, deltas and the Aral Sea,
- The salinity targets in the main rivers and the wetlands.

117. The rate and type of development in the irrigation sector are by far the most important factors determining future water and salt balances. Hence, scenarios have been developed and tested for the irrigation sector, with the other conditions or considerations being treated as sub-sets (alternatives) of the irrigation scenarios.

7.2 Data, Assumptions and Tools

7.2.1 Data

118. Water and salt balance calculations are highly dependent on data of what has been achieved and experienced in the recent past, the trends which can be derived from that, the expectations on what would be needed in future, and the constraints imposed to achieve sustainable resource management.

119. In developing the water and salt balances under various conditions, extensive use has been made of data provided by the National Working Groups. These data relate to the past and to the projections of potential future outlooks for each country as seen by the respective NWGs, following as far as possible frameworks for scenarios set out by the RWG. An overview is given in Chapter 5 of the ambitions of each country as set out in their draft national plans, as well as the Consultant's assessment of the overall feasibility and sustainability of the plans.

120. Data provided by the NWGs relates to:

- Population and its growth forecasts, and foodstuff production requirements,
- Hydrology,
- Agricultural production,

- Water quality (salinity),
- Irrigation areas,
- Condition of irrigation and drainage infrastructure (translated into irrigation efficiencies and return flows) under present conditions and under future improved conditions,
- Current and projected O&M costs,
- Investment requirements needed to achieve higher efficiency of water use and hence to achieve rational water use,
- Current crop yields and potential future higher crop yields as a result of the investments,
- Energy production and generation capacities.

121. During Phase III of the project, the RWG made an in-depth analysis of the current irrigation and drainage practices in Central Asia, and their impacts on agricultural production and soil salinisation. That study, entitled 'Water Losses and Development Strategies', then analysed a large number of options for improvement of on-farm water management, for various farm types and for the various regions in the Aral Sea Basin. Typical packages of improvement measures were put together for each area, and the economic feasibility of each package was assessed using crop and farm budgets developed specifically for those areas. The results of this work were summarised in Chapter 8 of Regional Report No.2.

122. The data used in the analyses of current and future water and salt balances hence covers a wide range of issues, and the database has become a rich and vast source of information. It should be realized that all data cannot easily be reproduced in this report, but the information is readily available in the above-mentioned reports and in the models. In Appendix 1 a summary is provided of the data used in the optimisation modelling work for the various scenarios evaluated.

123. The RWG has reviewed the NWG data and has made adjustments where needed to arrive at consistent data sets, which subsequently were checked by the NWG experts.

7.2.2 Assumptions

124. The National and Regional Working Groups have considered a number of scenarios for future regional water and salt management plans considering various needs and constraints.

125. Scenario I assumes a situation in which the irrigation systems would deteriorate further due to lack of funds for operation and maintenance. Water management would not improve, agricultural policies would not be reformed, etc. This would result in a negative picture of degrading lands, increased rural poverty, waste of water, lower production levels and a drag to the economic growth of the countries, which to varying degrees depend heavily on the agricultural sector. This scenario obviously is not desirable and is not an option of choice, and consequently no water and salt balance simulations or calculations of economic performance have been undertaken. However,

the assumptions of the scenario have been used as a basis for comparison in evaluating the performance of more desirable scenarios.

126. Scenario II assumes that the current level of performance (i.e. crop yields, system efficiency levels, etc.) in the agricultural sector would be maintained into the future, and that gradually the cropping patterns in each planning zone would be altered within constraining limits to achieve the optimum economic return. Constraints adopted were that any crop area should not decrease below 50% of the 1999 area of that crop, nor increase above levels set by population growth. In the case of Turkmenistan the changes in the constraints over time were not related to population growth but were nominated specifically.

127. Scenario III assumes substantial improvements in the performance of irrigated agriculture through investment in rehabilitation and reconstruction of main, inter-farm and on-farm water supply systems, and better on-farm water management leading to higher water productivity.

128. Especially for the Syr Darya basin, the above scenarios have been tested for various modes of operation of Toktogul Reservoir: (i) an 'irrigation mode' reflecting the design operation mode of the past, (ii) an 'energy mode' which gives higher priority to power generation in the non-vegetation season, and (iii) an ' irrigation and energy mode' which reflect the intentions of the annual agreements for the operating regime of recent years. In the case of Scenario IIIb, several variants of the irrigation and energy mode have been examined in order to demonstrate impacts on the national economies of certain choices, often of a political nature. The cases studied are summarised in the table below.

129. In all cases optimum land use is determined for each country, within defined water availability limits, operating mode of the reservoirs, available irrigable area, available funds, and logical limits to the cropped areas for certain crops. Through simulation modelling, the water and salt balances have been determined for each scenario.

130. The scenarios allow for future increases in energy consumption, and additional thermal and hydropower stations (such as Kambarata I and II, and Rogun) have been included to cover demands.

Table 23: Optimisation Cases Studied

Scenario No.	Scenario Description	Case	Mode of Operation of Toktogul	Variant No.	Variant Description
II	Maintain current productivity levels over time	a	Irrigation		Optimum productivity
		b	Energy/Irrig.		Optimum productivity
		c	Energy		Optimum productivity
III	Substantial investment, improved productivity over time	a	Irrigation		Optimum productivity
		b	Energy/Irrig.	1	Optimum productivity
				2	Self sufficiency
				3	Ecological
				4	Dry year
		c	Energy		Optimum productivity

131. The ‘self-sufficiency’ variant assumes a gradually phasing out of the self-sufficiency policy for cereals, especially wheat production. From an economic point of view wheat is an unprofitable crop for which imports can substitute, making larger areas available for profitable crops.

132. The ‘ecological’ variant studies the impact on water supplies to the various countries, and on farm productivity, of supplying the necessary volumes of water to the Northern and Larger Aral Seas for environmental sustainability. These have been shown to comprise minimum annual average flow requirements in the lower reaches of the rivers of 18 km^3 for the Amu Darya and 11.5 km^3 for the Syr Darya, totalling 29.5 km^3 per year in all.

133. Model tests initially focused on average flow conditions in order to be able to compare the performance of scenarios under normal conditions, but Scenartio IIIb has also been tested for dry year conditions, taking into account the multi-year storage facility of Toktogul reservoir. The ‘dry year’ variant considers the situation with annual river flows at a once in 10 year exceedence level i.e. with an annual total flow that is exceeded in 90% of years, and examines the impacts that the resulting water shortages have on farm productivity.

7.2.3 Tools

134. The optimisation model ASBOM and simulation models RIBASIM were developed during Phase III of the project. In the optimisation model, country-specific data, limits and constraints are specified for each irrigation system (planning zone) and for the energy sector. Maximum levels of investment can be specified for each country and new irrigation development can be allowed for.

135. In all cases optimum land use is determined for each country, within defined water availability limits, operating mode of the reservoirs, available irrigable area per planning zone, available funds, and logical limits to the cropped areas for certain crops.

Through simulation modelling, the water and salt balances have been determined for the optimised land use for each scenario.

136. Calibration of the optimisation model has been executed for the year 1999. The NWGs provided all used data in the national tasks which have been conducted throughout phase III and IV of the project.

137. During the calibration, the cropping patterns, net water use, generated energy and river flows were accepted as fixed parameters. The efficiency was the variable with which the whole basin was calibrated.

138. In order to view the possibilities, with respect to the economic performance, of the basin and the model a free optimisation run was conducted for the 1999 inflow data. In this case the crop pattern as given by the countries was used. The model optimised the land use, only restricted by its physical constraint. The difference between the real 1999 outcome and the optimal 1999 outcome are remarkable.

139. However, the 1999 optimisation with no restrictions on land use is not a realistic option as the model puts each planning zone under the most feasible crop. Depending on water availability and economical values the model put the whole basin under orchards and vegetables.

140. Therefore a 1999 realistic optimisation mode has been executed in which orchards and vegetables were constrained by the 1999 real crop pattern as maximum and winter wheat was constrained with the real 1999 crop pattern as a minimum.

141. It has been taken into account in the scenarios for the future that energy consumption will increase by 2.5% per year, and additional thermal and hydropower stations (such as Kambarata 1 and 2, Rogun, and the diversion of Piandj water to the Vaksh basin through a tunnel) have been included to cover demands.

Future Use of Models

142. The models developed under the project provide powerful tools to test and evaluate any development and management scenarios that interested parties may wish to have analyzed, for example in the context of preparation of interstate agreements. For example, constraints on the water allocation limits for each country can be applied according to the rules of the ‘corrected complex schemes’, but also other allocation limits can be applied and tested. Hence, it is foreseen that the software, the models and the database will be made available to EC-IFAS and the relevant agencies in the five countries for future use.

143. Later in 2002, the consultant will provide training to experts of the countries who will be involved in future modelling work. Manuals will also be made available.

7.3 Outcomes of Scenarios

144. The results of the optimisation studies carried out by the Regional Working Group are presented in Table 24 in terms of the various operating modes of Toktogul reservoir.

Table 24. Total Net Benefits ($US million/year) for the Amu Darya and the Syr Darya basins in 2025

	Kazakhstan	Kyrgyzstan	Tadjikistan	Turkmenistan	Uzbekistan
with Toktogul operated in the irrigation mode					
Scenario IIa	550	220	797	268	689
Scenario IIIa	634	242	828	488	1,201
with Toktogul operated in the irrigation-power mode					
Scenario IIb	575	232	799	268	684
Scenario IIIb1	644	253	830	488	1,196
Scenario IIIb2	520	213	875	464	794
Scenario IIIb3	631	233	840	412	895
Scenario IIIb4	637	216	758	417	1,105
with Toktogul operated in the energy mode					
Scenario IIc	591	239	803	268	640
Scenario IIIc	703	261	833	488	1,101

Optimal Cropping Patterns/Food Self-sufficiency

145. Estimates by the Regional Working Group show a cereal demand of some 11 million tonnes in 2025 for a population of 70 million in the Aral Sea Basin as projected by the NWGs. The wheat and rice production figures in the self-efficiency scenario show that this would be possible to achieve.

146. Comparison of the results for Scenarios IIIb1 and IIIb2 indicate that, in the case of most of the countries, the policy of self-sufficiency leads to substantially lower total benefits compared with what could be achieved in the optimum situation. This is particularly so in the case of Uzbekistan for which annual economic losses of about $400 million per year are indicated, a reduction of 33% from the optimum. The impact is also significant in Kazakhstan, where annual losses of $124 million or about 20% are indicated. The other countries are shown to be less affected. The cost of importing wheat or other grains should also be taken into account, and this would reduce the benefits in the optimum case, but the reduction is likely to be substantially less that the increased benefits from the substituted crops.

147. Thus, self-sufficiency in cereals has a heavy economic penalty. The benefits, which are related mainly to surety of food supplies, must be weighed against the costs arising from using valuable water resources in the irrigation of low value crops.

Ecological Flows

148. Comparison of Scenarios IIIb1 and IIIb3 gives the effects of providing minimum flows to the Aral Sea and wetlands for sustainability, assuming cropping patterns for optimum productivity. The results indicate that there would be relatively little impact in Kazakhstan, Kyrgyzstan and Tadjikistan. There would be a reduction in benefits of $300 million per year in Uzbekistan, or 25%, while Turkmenistan would suffer a loss of benefit of $76 million or 15%.

Toktogul Operating Mode

149. It is clear that, purely from the economic point of view:

- The choice of operation mode for Toktogul reservoir has an impact on the economic performance. The model studies confirm that overall the irrigation mode of operation favours the downstream countries, while the opposite holds for the energy mode.
- A compromise, a combined irrigation-power mode of operation of Toktogul as compared to the original irrigation mode of operation (Scenario IIIa compared with Scenario IIIb1), results in an $11 million per year or 4.5% increase in the benefits for Kyrgyzstan, and a $5 million per year or 0.4% decrease for Uzbekistan. The benefit to Kazakhstan would increase by1.5%. The other countries would be unaffected.
- When looked at from the other side, the benefits for Kyrgyzstan under Scenario III in the irrigation mode are $11 million per year or 4.7% less than in the compromise mode and $19 million per year or 7.9% when compared to the energy mode of operation. In the case of Uzbekistan the energy mode of operation results in a decrease in benefits of the order of $ 100 million per year. Kazakhstan would benefit also from the energy mode due to the rehabilitated Chardara dam and HPS.

7.4 Current and Future Water and Salt Balances

7.4.1 Details of Balance Studies

150. The simulation model was used to determine the water and salt balances in the planning zones over a period of 40 years for the land use of 1999. The results are presented in Appendix 1. Detailed water balances comprising inflows, reservoir losses to evaporation, reservoir storage change, intakes to the planning zones, return flows from the planning zones, flows out of the system into end reservoirs, can be reviewed on the website http://www.aral.uz under Sub-component A1.

7.4.2 Regional and Planning Zone Water Balances

151. The Regional Working Group has undertaken an analysis of the water and salt balance conditions that would prevail in the Aral Sea Basin in the future under the situations described in the *draft water and salt management national plans*. The analysis has involved simulation studies using the RIBASIM model to assess the performance of the supply system under the assumed future conditions for various scenarios, using historical river flow records over 40 years.

152. The results show that the expected future water demands (including a sanitary flow of 3.1 km^3) in the Amu Darya basin would increase from 59.9 km^3/year at present to 68.2 km^3/year by about 2025. Shortages in supply would increase from 2.6 km^3/year to 11.4 km^3/year. The results indicate that shortages in the vegetation period would be pronounced in several systems: Surkhandarya (35%), Kashkadarya (23%), and Bukhara (34%), while the Akhalsk and Balkan areas would suffer very large deficits. All other irrigation systems would be supplied with sufficient water in vegetation period or would only have minor shortages occasionally. Deficits would not occur in the non-vegetation period.

153. In regard to the Syr Darya the studies indicate that under the future conditions total water demands (including a sanitary demand of 1.6 km^3) would decrease from the current 42.9 km^3/year to 32.8 km^3/year in 2025. Shortages in supply would be minimal.

154. Noteworthy conclusions from the results of the studies are that, with the development and cropping patterns envisaged in the draft national plans:

- Adequate flows for sanitary purposes would be maintained throughout both rivers.
- The river flow in the Syr Darya available for wetlands and the Aral Sea would increase from 3 km^3/year to 5 km^3/year, while in the Amu Darya it would decrease from 8.8 km^3/year to 8.2 km^3/year.
- The level of the Larger Aral Sea would fall another 7 m, while the level of the Northern Aral Sea would stabilise or rise slightly.
- Downstream river water salinity levels would decrease minimally, from an average value in the Amu Darya of 0.8 g/l to 0.77 g/l, with a similar trend in the Syr Darya. Peak values would similarly decrease.
- Due to substantial reductions in the volumes of water supplied per hectare, salt accumulation in the sub-soil, and salt export to desert sinks or rivers, would decrease substantially overall.

155. The land and water use determined in the optimisation modelling has been simulated for the various scenarios developed by the Regional Working Group. In all of the cases investigated the supply deficits are minimal. This is because in each case land use was optimised within the boundaries of average water availability and water allocation limits. Hence shortages are indicated for systems that are entirely or mainly supplied from tributary flow, or are located at the ends of the main stems of the major rivers.

156. With one exception, the total water intake in the Amu Darya Basin was found to be around 57 km^3 per year, ranging from 55.6 km^3 to 60.0 km^3 depending on the scenario. The exception is the scenario giving a high priority to the wetlands and the Aral Sea, in which case the total intake was shown to be limited to about 47 km^3 per year.

157. The total water intake in the Syr Darya basin is found to be around 40 km3 per year, ranging from 40.9 km^3 to 36.5 km^3, with the exception of the scenario giving priority to the wetlands and the Aral Sea when the total intake would be limited to 31.6 km^3 per year.

158. Overall, the total water intake for irrigation in the Aral Sea Basin is shown to be about 100 km^3 per year.

159. A number of other options for water management and irrigation development will be evaluated during Phase VI, as suggested by the various national teams, the World Bank, and the Independent Panel of Experts.

7.4.3 Regional and Planning Zone Salt Balances

160. The RIBASIM model has been used to calculate the average annual change in salt storage in all planning zones. The change in salt storage (the salt balance) is expressed in terms of t/ha. When it is negative, more salt is leaving the planning zone

than entering, and this may affect areas further downstream. When it is positive then salt is accumulating in the zone, and this can lead to crop yield reductions.

161. The results of the model studies for all planning zones in the Aral Sea Basin are shown in Table 25 and Table 26.

Table 25: Average Yearly Planning Zone Salt Balances (t/ha) in the Syr Darya Basin

Country	Planning Zone	Present conditions	Scenario 2	Scenario 3 (optimum)	Self sufficiency	Ecological
Kyr	Naryn Upper Reach	n/c	n/c	n/c	n/c	n/c
Kyr	Naryn Middle U/S	1.7	1.6	2.5	1.9	1.9
Kyr	Naryn Middle D/S	1.7	1.6	2.5	1.9	1.9
Kyr	Fergana North	2.0	2.0	2.5	1.8	2.3
Uzb	Namangan Naryn	-1.7	-2.1	-0.3	-0.5	-0.3
Kyr	Kampyr Ravat	2.8	3.2	3.7	3.7	3.7
Uzb	Andijan	-5.4	-4.4	-0.9	-0.7	-0.9
Uzb	Fergana	-8.0	-3.0	-1.9	-1.6	-2.0
Kyr	Fergana South	-1.3	0.3	1.0	0.9	1.4
Uzb	Namangan Syr Darya	1.4	2.2	2.2	2.0	1.5
Tad	Khodjent	5.9	6.3	4.9	4.0	2.4
Uzb	Tashkent Syr Darya	6.9	8.4	5.8	5.2	3.2
Uzb	Syr Darya	-0.9	-0.4	0.2	-1.0	-1.6
Uzb	Djizak	-3.2	-3.6	-1.9	-2.2	-3.6
Kaz	Hunger Steppe	0.8	0.8	0.6	1.3	-0.6
Uzb	Tashkent Chirchik	-2.3	-2.6	-1.3	-1.2	-1.2
Kaz	Chakir	-3.9	-4.9	-1.9	-1.4	-1.7
Kaz	Kzylkum	5.3	5.0	4.6	3.7	4.2
Kaz	Artur	-0.3	-0.4	0.0	0.0	0.0
Kaz	Kzylorda	23.8	28.7	21.3	13.6	17.9

Table 26: Average Yearly Planning Zone Salt Balances (t/ha) in the Amu Darya Basin

Country	Planning Zone	Present conditions	Scenario 2	Scenario 3 (optimum)	Self sufficiency	Ecological
Tad	Garm	n/c	n/c	n/c	n/c	n/c
Tad	Gorno Badakshan	2.0	2.0	2.3	2.1	2.2
Tad	Pyandj	1.1	-0.5	1.7	1.7	1.7
Tad	Vaksh	1.0	0.9	1.7	1.8	1.7
Tad	Kafirnigan Upper	0.0	0.0	0.5	0.4	0.4
Tad	Karatag Shirkent	0.0	0.0	0.5	0.5	0.4
Tad	Kafirnigan Lower	0.4	0.4	0.6	0.7	0.6
Uzb	Surkhandarya	-7.3	-7.8	-3.5	-2.7	-2.9
Tur	Mary	-32.1	-32.0	-21.0	-20.9	-19.7
Tur	Akhalsk	-34.6	-34.6	-26.5	-23.7	-26.2
Tur	Balkan	-20.0	-19.9	-15.7	-11.2	-17.3
Uzb	Kaskhadarya	-7.1	-7.1	-3.8	-2.5	-4.2
Uzb	Karshi	-11.9	-11.8	-5.8	-3.7	-6.3
Tur	Lebab	-8.0	-7.9	-4.2	-4.1	-4.0
Tad	Zarafshan	n/c	n/c	n/c	n/c	n/c
Uzb	Samarkand	n/c	n/c	n/c	n/c	n/c
Uzb	Navoi	-13.1	-13.0	-6.7	-6.1	-6.3
Uzb	Bukhara	-10.3	-10.9	-0.1	-3.0	-6.0
Uzb	Khorezm	9.0	9.3	4.2	4.3	4.2
Uzb	Karakalpakstan South	5.9	6.2	3.4	2.5	3.5
Tur	Dashkovus	3.4	2.5	1.0	5.6	5.6
Uzb	Karakalpakstan North	5.6	6.0	3.2	2.1	3.5

Present conditions

162. Annual changes of more than 2 t/ha are considered to be significant. With annual changes of less than that value it is considered that a zone is more or less in equilibrium, within the level of accuracy of the studies. On that basis the results indicate that, under present conditions, there are significant negative salt balances in the following planning zones: Chakir, Andijan, Fergana, Tashkent Chirchik and Djizak i.e. at present there is a net export of salt from these zones. Significant positive salt balances are indicated for the planning zones: Kampyr Ravat, Khodjent, Tashkent Syr Darya, Kyzyl Kum and especially Kyzyl Orda; salt is therefore accumulating in these zones. In the remaining planning zones the salt balances in equilibrium.

163. The results are similar for the Amu Darya Basin. They show that significant negative salt balances exist in the following planning zones: Surkhandarya, Mary, Akhalsk, Balkan, Kashkadarya, Karshi, Lebab, Navoi and Buchara. In these planning zones there is at present a net export of salts. Significant positive salt balances are indicated for the planning zones situated in the delta of the Amu Darya: Khorezm,

Karakalpakstan South and North and Dashkovus; salt is therefore accumulating in these zones. In the remaining planning zones the salt balances are in equilibrium.

164. The objective for all planning zones is eventually to create conditions in which salt balances are in equilibrium.

Salt balances under future conditions

165. From the results it is concluded that, under Scenario 3, the proposed measures lead to a higher number of planning zones with salt balances in a state of equilibrium. The results indicate that salt exports will reduce in planning zones where at present high salt loads are being exported, notably Ferghana and Andijan in the Syr Darya basin and most of the planning zones in Turkmenistan. A reduction in salt accumulation is indicated in Kyzyl Orda, which receives by far the greatest imports of salt, and in planning zones in the Amu Darya delta.

166. In the Syr Darya basin, the self-sufficiency case appears to offer the greatest reductions in salt balance, with only 5 planning zones showing balances greater than 2 t/ha. The ecological case also offers considerable reductions. In the Amu Darya basin the self-sufficiency case generally offers higher reductions in the salt balances in the midstream and downstream planning zones.

167. Overall, the results suggest that measures involving more efficient water use and improved agricultural practices can lead to more favourable salt balances in the Aral Sea Basin. In the longer term the downstream irrigation areas, the wetlands, the floodplains and the Aral Sea itself will profit from these policies and strategies to be implemented.

7.5 Key Outcomes

168. Measures to enhance water productivity and freedom of choice regarding the crops to grow, within certain limits, would lead to much higher benefits to the National economies. The key indicators derived from the Scenarios are presented in Table 27.

169. The projected agricultural production and water productivity figures demonstrate that an enormous growth potential exists in the irrigated agriculture, at least when the conditions needed to achieve that are being met.

170. In the Scenario III cases, no expansion of irrigated areas has been assumed due to the uneconomic nature of new land development (see Appendix 3).

171. It should be noted also that the growth can be achieved at substantially lower levels of investment compared to the figures quoted by the draft National Plans (which total some $40 billion). Even then, the amount of $20 billion of investments in Scenario III over a 25-year period will be a heavy burden on the government budgets, especially for the coming decade when the role of private investment is still expected to be low. Hence, it is most likely that, over the next ten years, development will follow a scenario somewhere between Scenarios II and III.

172. The salt balances for the planning zones, and the salt concentrations in the main stem, can be expected to reduce as a result of implementation of a water and salt management strategy that aims at stabilizing the groundwater tables at a lower levels then at present. Measures to achieve this relate to improvement of irrigation practices,

rehabilitation of supply and drainage networks, and the introduction of subsurface drainage.

Table 27: Key Indicators for Scenarios

Indicator	Current Situation	2025 Values			
		Scenario 2	Scenario 3 (Irr-Power mode)		
			Optimum	Self-suffic'y	Ecological
Agricultural Production: Cotton (million t/yr)	4.58	6.31	9.10	7.76	6.18
Wheat (million t/yr)	5.66	3.02	3.86	10.47	3.99
Rice (million t/yr)	0.86	0.64	1.14	0.65	0.86
Water Productivity (production): Cotton (t/'000m^3)					
* Kazakhstan	0.31	0.13	0.18	0.19	0.19
* Kyrgyzstan	0.17	0.18	0.22	0.23	0.27
* Tadjikistan(2)	0.11	0.13	0.16	0.16	0.16
* Turkmenistan	0.15	0.14	0.22	0.22	0.22
* Uzbekistan(2)	0.16	0.14	0.22	0.23	0.23
Water Productivity (production): Wheat (t/'000m^3)					
* Kazakhstan	0.18	0.29	0.29	0.27	0.29
* Kyrgyzstan	0.35	0.45	0.45	0.47	0.47
* Tadjikistan(2)	0.20	0.29	0.29	0.27	0.34
* Turkmenistan	0.23	0.24	0.24	0.29	0.27
* Uzbekistan(2)	0.47	0.38	0.52	0.48	0.64
Water Productivity (Value): Cotton ($US/'000m^3)					
* Kazakhstan	3.40	2.60	12.16	13.16	13.64
* Kyrgyzstan	15.10	17.10	24.63	29.98	32.39
* Tadjikistan(2)	0.60	3.40	3.35	2.81	3.18
* Turkmenistan	7.20	9.80	24.55	24.38	26.30
* Uzbekistan(2)	7.60	10.40	25.59	23.48	23.46
Water Productivity (Value): Wheat ($US/'000m^3)					
* Kazakhstan	-19.23	-31.22	-31.22	-29.35	-31.22
* Kyrgyzstan	1.92	2.45	2.45	2.74	2.78
* Tadjikistan(2)	-4.63	-4.63	-4.55	-5.59	-5.80
* Turkmenistan	-18.29	-18.77	-18.84	-20.78	-19.27
* Uzbekistan(2)	-15.66	-12.70	-8.75	-11.90	-17.25
Water balances for critical planning zones (km^3/yr) (% of demand)					
* *Ferghana Valley*	99	83	81	91	100(3)
* *Syr Darya (South Hunger Steppe)*	100	100	100	100	100(3)
* *Kyzyl Orda*	99	99	98	99	100(3)
* *Lebap*	100	100	100	93	100(3)
* *North Karakalpakstan*	99	92	96	78	100(3)
Salt balances for critical planning zones (t/ha/yr) (export negative, import positive):					
* *Ferghana Valley*	-8.0	-3.0	-1.9	-1.6	-2.0
* *Syr Darya (South Hunger Steppe)*	-0.9	-0.4	0.2	-1.0	-1.6
* *Kyzyl Orda*	23.8	28.7	21.3	13.6	17.9
* *Lebap*	- 8.0	-7.9	-4.2	-4.1	-4.0
* *North Karakalpakstan*	5.6	6.0	3.2	2.1	3.5
Main stem sanitary flows (m^3/s): * Amu Darya	100	100	100	100	100
* Syr Darya	93(1)	93(1)	93(1)	93(1)	93(1)
Average flow to wetlands and Aral Sea (km^3/year):					
* Amu Darya	8.2	9.6	11.1	8.2	18.5
* Syr Darya	3.6	3.6	3.9	6.2	11.1
Water Intake (km^3/year) :					
Kazakhstan	12.8	8.3	11.1	9.3	9.1
Kyrgyzstan	5.0	5.1	5.2	4.1	3.9
Tadjikistan	9.7	7.5	6.7	7.8	7.4
Turkmenistan	19.2	22.3	22.3	22.3	16.7
Uzbekistan	52.4	52.3	49.1	53.2	37.6

Indicator	Current Situation	2025 Values			
		Scenario 2	Scenario 3 (Irr-Power mode)		
			Optimum	Self-suffic'y	Ecological
Total	99.1	95.5	94.4	96.7	74.7
Hydrologic Regimes (operating modes) * Amu Darya	Irrigation	Irrigation	Irrigation	Irrigation	Irrigation
* Syr Darya	Energy	Irrig-energy	Irrig-energy	Irrig-energy	Irrig-energy
Average lower end river salinity (g/l): * Amu Darya	1.1	1.1	1.1	1.2	1.0
* Syr Darya	1.1	1.2	1.0	0.9	0.9
Total area of irrigated land in Aral Sea Basin (mill. ha)(4)					
Kazakhstan	0.77	0.63	0.64	0.77	0.58
Kyrgyzstan	0.40	0.44	0.45	0.46	0.37
Tadjikistan	0.73	0.66	0.64	0.73	0.71
Turkmenistan	1.71	1.76	1.91	1.97	1.57
Uzbekistan	3.83	3.38	3.69	4.83	2.98
Total	7.44	6.87	7.34	8.76	6.21
Total investment over 25 years (extra to Scenario 2 investment) for maximum financial benefit ($USmill.)					
Kazakhstan			1,162	929	1,090
Kyrgyzstan			391	391	391
Tadjikistan			779	866	827
Turkmenistan			4,158	4,438	3,178
Uzbekistan			13,376	12,611	11,229
Total			19,866	19,235	16,715

1. 50 m^3/s in dry years
2. Average for Amu Darya and Syr Darya Basins
3. Reduced irrigated area allows irrigation demands to be met fully at all times
4. Total irrigable area in the Atal Sea Basin reported by the NWGs is about 10% more than the generally-reported 8 million hectares.

7.6 Implications for National and Regional Planning

173. The results obtained from the scenario evaluation demonstrate that it is possible - for the coming 5 to 10 years - to integrate the national interests into the regional context:

- within the water availability limits,
- within the current water allocation limits for the countries, and
- without an urgent need to expand irrigated areas.

174. This can be achieved through programmes and projects for rehabilitation of main, inter-farm and on-farm water infrastructure, changes in irrigation practices which are aimed at reducing water losses, increasing productivity of the water, and decreasing salinisation of the lands.

175. This overall conclusion should allow the NWGs to revise and enhance their draft National Plans during Phase VI in order for them to become more realistic and in line with the regional demands and constraints.

8. IMPROVED MECHANISMS FOR JOINT WATER RESOURCES MANAGEMENT

8.1 Current Water-sharing Arrangements

176. Following the decisions of the five Heads of State directly after Independence (Tashkent, 10-12 October 1991) the ministers of Water Resources of the five States made an official statement on consolidation of the efforts and joint coordination of the actions for effective solution of the water management problems of the region, and came to an agreement on ‘Cooperation in the sphere of joint management of use and conservation of water resources of interstate sources’ (Almaty, 18 February 1992). This agreement was confirmed by the Heads of State (Kyzyl Orda, 26 March 1993), and has since been the backbone of joint management of water resources in the Aral Sea Basin.

177. The agreement signed by all five countries in February 1992 on “Cooperation in the Sphere of Joint Management of Use and Conservation of Water Resources of Interstate Sources” is the basis of the present water relations between the Aral Sea Basin countries. There are also a number of bilateral and multilateral agreements for the individual river basins, which are based on the schemes and agreement of 1992 referred to above.

178. At present, water sharing between the countries in the Amu Darya river basin is based on a scheme (“Corrected scheme of complex use and conservation of water resources of Amu Darya River”) completed in 1987 by the Ministry of Water Management of the USSR. According to this scheme, the maximum irrigation development in the Amu Darya basin up to 1995, and associated annual water diversions *under 90% water availability*, were to be as follows:

Country	Maximum Irrigated Area (‘000 ha)	Allocated Diversion Volume (km^3/year)	%
Uzbekistan	2,940	29.6	48.2
Tadjikistan	576	9.5	15.4
Kyrgyzstan	65	0.4	0.6
Turkmenistan	1,350	22.0	35.8
Total	4,971	61.5	100.0

179. The flow in the Amu Darya which passes to the Kerki (Atamurat) gauging station is shared equally between Uzbekistan and Turkmenistan, with equal allocations (50:50) between countries, proportional sharing of the water allocation to the Aral Sea, and reduction of saline drainage water flows into rivers. These points are set down in a bilateral agreement of 16 January 1996, signed by the two Heads of States, on cooperation on water management issues.

180. The situation is different in the Syr Darya river basin. There, due to disagreements on water sharing, schemes of 1982, 1983 and 1984 were not always supported by some countries. The scheme that is now followed specifies the following

maximum irrigation development in the basin and associated water allocations *under 90% guaranteed water availability*:

Country	Maximum Irrigated Area ('000 ha)	Allocated Diversion Volume (km^3/year)	%
Uzbekistan	1,892	19.69	51.1
Kazakhstan	780	12.39	32.1
Kyrgyzstan	456	4.03	10.4
Tadjikistan	262	2.46	6.4
Total	3,390	38.47	100.0

181. From a broad perspective the 1998 draft Agreements (prepared from 1998 onward during WARMAP-2) on the institutional structure of joint management, protection and development of the water resources in the Aral Sea Basin between the five States (No.1), and on the use of water resources between the States (No.2), are very comprehensive and read well. However, it is suspected the reason they were not signed was because they were too detailed, notwithstanding the fact they were understood to be 'framework' agreements, and as a result they 'invited' objections or disagreement to specific articles or volumes from at least one State - for example, with respect to the volumes of water for ecological purposes to the Aral Sea and the Aral Sea delta systems (Article 5, No.2). Hence, the two draft agreements have not yet reached sufficient consensus to be proposed to the IFAS Board for discussion and approval.

182. It is suggested the most practical way forward is to seek agreement on a broad framework for basin-wide institutional arrangements, and then to sort out water sharing arrangements and specific operational details and functions later. To attempt to obtain agreement from five States on every conceivable detail before moving forward is considered an exercise in futility and a waste of time.

183. The facts are:

- The States **agree** that they must cooperate to jointly manage the water resources of the Aral Sea Basin to ensure sustainable development, which fact has been endorsed on a number of occasions by the Heads of State; but
- The States **do not agree** on every detail of how that 'cooperation' might translate in practice, which, given their respective political, economic, environmental and social priorities, and their geographic locations in the basin, is not surprising.

184. It is suggested that the way ahead then is to agree 'in principle' on a broad institutional framework objective i.e. to meet on 'common ground', and then to move forward one step at a time.

8.2 Definition of Transboundary Waters

185. The 1992 agreement in its title and in various articles specifies that it relates to *"use and conservation of water resources of interstate sources"*. No definition of water

resources of interstate sources was given in the agreement, however, and since that time attempts have been made to come to a common understanding on the subject. A firm definition is important because the parties to the agreement have to know *what* they intend to manage jointly.

186. In this respect it is proposed that the five States adopt the definition provided by the UN/ECE 'Convention on the Protection and Use of Transboundary Watercourses and International Lakes', Helsinki, 1992. The convention came into force on 6 October 1996. It specifies that '"Transboundary waters" means any surface or ground waters which mark, cross or are located on boundaries between two or more States; wherever transboundary waters flow directly into the sea, these transboundary waters end at a straight line across their respective mouths between points on the low-water line of their banks'.

187. The definition is sufficiently robust to be applicable in the Aral Sea Basin, in the sense that it fits closely with the well-established practice of cooperation in joint management of the water resources of the basin and sub-basins over the past decades.

188. When this definition is applied in the Aral Sea Basin, the following waters would be 'transboundary waters':

Surface waters

Piandj	Tadjikistan, Afghanistan
Kyzyl Su	Kyrgyzstan, Tadjikistan
Zerafshan	Tadjikistan, Uzbekistan
Amu Darya	Tadjikistan, Turkmenistan, Uzbekistan, Afghanistan
Surkhandarya	Tadjikistan,Uzbekistan
Karshi Main Cascade	Turkmenistan, Uzbekistan
Amu Bukhara Main Canal	Turkmenistan, Uzbekistan
Tashaka Canal	Turkmenistan, Uzbekistan
Klychbay Canal	Turkmenistan, Uzbekistan
Kipchakbozsu Canal	Turkmenistan, Uzbekistan
Murgab	Turkmenistan, Afghanistan
Tedjen	Turkmenistan, Iran and Afghanistan
Naryn	Kyrgyzstan, Uzbekistan
Karadarya	Kyrgyzstan Uzbekistan
Syr Darya	Uzbekistan, Tadjikistan, Kazakhstan
Chirchik	Kazakhstan, Uzbekistan
Bozsu	Kazakhstan, Uzbekistan
Ugam	Kazakhstan, Uzbekistan
Dostlik Canal	Uzbekistan, Kazakhstan
Zakh Canal	Uzbekistan, Kazakhstan
Khanym Canal	Uzbekistan, Kazakhstan
Achinau Canal	Uzbekistan, Kazakhstan
Gazalkent Diversion Canal	Uzbekistan, Kazakhstan
Chatkal	Kyrgyzstan, Uzbekistan
Gavasai	Kyrgyzstan, Uzbekistan
Sumsar	Kyrgyzstan, Uzbekistan
Kasansai	Kyrgyzstan, Uzbekistan

Chanach	Kyrgyzstan, Uzbekistan
Podshaota	Kyrgyzstan, Uzbekistan
Mailisuu	Kyrgyzstan, Uzbekistan
Karaungur	Kyrgyzstan, Uzbekistan
Kugart	Kyrgyzstan, Uzbekistan
Akbura	Kyrgyzstan, Uzbekistan
Aravansai	Kyrgyzstan, Uzbekistan
Isfairamsai	Kyrgyzstan, Uzbekistan
Shakhimardan	Kyrgyzstan, Uzbekistan
Sokh	Kyrgyzstan, Uzbekistan
Isfara	Kyrgyzstan, Tadjikistan, Uzbekistan
Khodji-Bakirgan	Kyrgyzstan, Tadjikistan
Aksuu	Kyrgyzstan, Tadjikistan
Groundwaters	
Aquifers at the fringe of the Ferghana Valley	Kyrgyzstan, Uzbekistan
Aquifers between Termez and Uchbersen	Uzbekistan, Turkmenistan
Aquifers in the Zerafshan River valley	Tadjikistan, Uzbekistan

8.3 National Viewpoints on Transboundary Waters

Kazakhstan

189. Kazakhstan does not consider transboundary water resources to be an exclusive national property. Kazakhstan adheres to international rules, and in October 2000 it joined the 1992 Helsinki Convention on the Protection and Use of Transboundary Watercourses and International Lakes.

Kyrgyzstan

190. The viewpoint of the Kyrgyz government is that all water in the Republic originates there, and therefore that all water is the property of the State. However, the country signed the interstate framework agreement on the rational use of water and energy resources. The 1993 Agreement ‘On Joint Actions on the Aral Sea Basin’ signed by the Heads of Central Asian States was concluded for a ten-year period and can be considered for extension for a similar period. However, Kyrgyzstan has not ratified international water conventions because it considers that the relationship between the rules of ‘reasonable use’ and of ‘not causing appreciable harm’ is unclear.

Tadjikistan

191. Tadjikistan disagrees strongly with the separation of transboundary and national waters, and considers it unfair that Amu Darya water is considered to be transboundary in the territory of Tadjikistan but after leaving the country it becomes the national property of Turkmenistan and Uzbekistan. Tadjikistan believes that the main issue to be solved is the choice of criteria for the distribution of water between the countries in the region, and that it is necessary to follow the principles of international law in a new approach to water distribution. Tadjikistan advocates the regional approach and is not in favour of water management agreements at the level of the two basins.

Turkmenistan

192. Turkmenistan's viewpoint is that the Amu Darya and Syr Darya are transboundary rivers, but there is no need to define national and transboundary waters in detail. The existing 1996 agreement 'About Cooperation on Water Management Issues' between Turkmenistan and Uzbekistan is considered by them to be a satisfactory arrangement. That agreement specifies that the two States share the water of the Amu Darya entering these two countries equally between them, and that from 1999 saline drainage return flows to the Amu Darya must be stopped.

Uzbekistan

193. Uzbekistan holds the view that transboundary waters should be assessed in the context of international water law, possibly using the Helsinki Convention as a basis for discussion. On the issue of national and transboundary waters, at least 80% of the waters used in Uzbekistan originate from upstream riparian States, and it is considered more important to discuss joint water management than attempting to define and delineate national and transboundary waters in detail. It is considered that the existing 1993 agreement 'On Joint Actions on the Aral Sea Basin' should be used as a starting point to discuss changes in seasonal allocations while maintaining the overall annual share of each country. Uzbekistan considers that it might be appropriate to negotiate separate agreements for the Syr Darya and the Amu Darya Basins.

8.4 Review of Interstate Water Allocations

194. The 1992 agreement departs from, amongst others, the principle "to respect current structure and principles of allocation and based on normative documents on allocation of water resources of interstate sources". It "also takes into consideration that in the Republic of Tadjikistan there is disproportion of irrigated area provision per capita, recognising possible increase of water supply of irrigated agriculture". In 1996 the ICAS confirmed that the agreement would remain in force until a regional water management strategy had been formulated that responds to the realities and is adopted by all countries.

195. It may be concluded from the above statements that the intention of the States has always been to respect closely the former Soviet Union water allocation principles. However, at the same time these existing agreements do leave room for adjustments to be considered, e.g. for Tadjikistan possibly in the framework of the development of new strategies.

196. The three downstream countries have expressed the view that the currently prevailing water allocations for each country are of crucial importance and have to be maintained.

197. The situation is different for the upstream countries. In the draft national water management plans, Kyrgyzstan and Tadjikistan propose to expand the irrigated areas with subsequently higher diversions of water. Kyrgyzstan does have other river basins, and its focus for the Naryn sub-basin is more on the optimal use of the cascade of reservoirs for power generation. This has already led over the past decade to a remarkable change in seasonal flows, affecting the downstream countries.

198. At present there seems not to be sufficient common ground, nor is there an urgent need, to expect that water allocations between States may change in the near future. Although there may be arguments in favour of allocating more water to the upstream countries, it follows more or less automatically that this will be to the detriment of the delta areas, wetland ecosystems, the Aral Sea shore and the Aral Sea, and these would have literally no voice in the decision-making process. Moreover, with the limited economic capacities of the upstream countries, new irrigation development will probably come about slowly.

199. Although the issue of interstate water allocation is considered to be a sensitive and contentious one, the States cannot avoid discussions of it in the near future. Sustainable water management and water resources protection are essential for the social and economic well being of the States' populations.

200. In the long term, however, there may be more pressure for change. When the subject is examined objectively and independently, it can be concluded that there are a number of sound arguments why it would be reasonable in the future to reconsider the water allocation limits. They are:

- The former allocations were developed under the former Soviet Union, based on principles of a centrally controlled economy.
- The political, social and economic environments in each of the countries have undergone profound changes since Independence.
- The former allocations were not always agreed upon by some of the republics, but were, or had to be, respected.
- Agriculture was developed to the maximum extent possible, and consequently the river regime followed the demand pattern dictated by that use.
- The current situation is different from that applying at the time of the agreement in that, for well-known reasons, the regime of the Syr Darya has changed. In principle, therefore, this water use deviates from the complex scheme provisions.
- The allocations were determined with little or no regard for the need to support wetland ecosystems and the Aral Sea shores.
- The aim in determining the allocations was to use the waters of the basin to their complete exhaustion, leaving only surplus water in high flood years to reach the Aral Sea.
- Although the Amu Darya scheme has a limited allocation for Afghanistan of 2.1 km^3/year, and there has been no participation by that country in basin management, in the foreseeable future it can be expected that it will wish to become a partner in regional water management issues.
- It is recognised in the Agreement of 1992 that Tadjikistan in particular could be entitled to a larger allocation.

8.5 Options for Improved Management of the Naryn Syr Darya Cascade

8.5.1 <u>Introduction</u>

201. The collapse of the former Central Asian water-energy exchange system after Independence made it difficult to maintain an operational system through the 1990s. Consequently, in 1998 Kazakhstan, Kyrgyzstan and Uzbekistan entered into an interstate

framework agreement on the rational use of water and energy resources of the NSDC (Appendix 4). Tadjikistan joined the agreement in 1999 and this framework has since formed the basis for annual negotiations about specific amounts of water to be released and energy to be exchanged, and how these amounts are to be compensated and/or paid for.

202. The objective of the annual Syr Darya agreements between the governments of Uzbekistan and Kyrgyzstan, and between the governments of Kazakhstan and Kyrgyzstan, is to specify compensation deliveries of fossil fuel resources from the downstream countries to Kyrgyzstan in return for electrical energy delivered in summer time. Volumes of these supplies are established annually based on the forecast hydrological situation and water reserves in Toktogul reservoir. The compensation has mainly been in the form of coal, natural gas and heavy fuel oil (mazut). There have been problems in the past resulting from interruptions to gas supplies and the, at times, poor quality of gas and coal delivered to Kyrgyzstan, with consequent high releases of water in winter to provide Kyrgyzstan energy requirements, and resulting wastage of water to Lake Arnasay.

203. There is a steady decline in the water reserves in Toktogul reservoir, which, if it continues, will result in a critical situation in regard to energy and irrigation supplies. Incomplete or untimely fulfilment of their obligations by the parties to the agreements, and unbalanced use of the hydro resources of the Naryn River, will inevitably result in serious consequences for the water and energy systems in the region.

204. Major issues include:

- Kyrgyzstan has a structural deficit in electricity generating capacity and no quick and affordable solutions are available. Construction of Kambarata I and II is not envisaged in the NWG draft plan for the near future, mainly because of the size of the investment, while construction of thermal power stations is not a realistic option. Technical and commercial losses of electricity are very high in Kyrgyzstan, about 35% of the generated energy being reported as losses.
- There is a need to develop an agreed river regulation and electrical generation regime for the Syr Darya-Naryn system that is sustainable in the long term i.e. that does not continue to draw down Toktogul reservoir on a long-term basis.
- There is a need for a mechanism to ensure that all parties to the agreements fulfil their obligations under the agreements, or if this cannot be achieved (in the event of a gas transmission failure, for example), that there is timely notification of the failure and that appropriate compensation is made.

205. There is a similar agreement between Uzbekistan and Tadjikistan which stipulates (i) the volume of water to be released and the amount of electricity to be taken by Uzbekistan in the vegetation period and (ii) the amount of electricity to be delivered by Uzbekistan in winter, plus spare parts, lubricants and other supplies and services for maintenance of Kayrakkum reservoir.

206. A number of options can be considered for improvement of the management of the Naryn Syr Darya Cascade, including:

- Continuation of the existing agreement with some modifications,
- Continuation of the existing agreement with major modifications,
- Continuation of the existing agreement with structural modifications,
- Discontinuation or modification of the agreement for entering into a Water and Energy Consortium,
- Prolongation of the existing agreement without modifications.

207. The first four options are considered in more detail in the following sections.

8.5.2 Continuation of the 1998 Agreement with Some Modifications

208. This option would focus on removing a number of weak or ill-defined points in various articles of the framework agreement.

209. Article II could be amended by moving the first sentence of Article VIII, about the decision-making process and the role of the Vice-prime Ministers, to the end of Article II.

210. Article III could be extended to include the condition that in case a party to the agreement is not able to fulfil its obligations, timely notification of the nature and extent of the failure is to be given to the affected party and prompt action on appropriate compensation is to be agreed upon between the parties concerned.

211. The second paragraph of Article IV could be amended to: 'compensation shall be made in monetary terms as agreed upon, or in equivalent amounts of energy resources such as coal, gas, electricity or fuel oil, and other types of products (labour, services) for annual and multiyear irrigation water storage in the reservoir.

212. The third paragraph of Article IV could be specified more clearly, as for instance: 'A uniform tariff policy for all types of energy sources and their transportation shall be applied between the parties for mutual settlement of energy flows falling under this agreement. The uniform tariff policy is based on adopting average quarterly world market prices for coal, gas, electricity and fuel oil published by the International Energy Agency based in Paris, adjusted for quality, and multiplied by a single factor to be approved by annual agreements between all parties, and increased to cover the cost of transportation from the source to the point of delivery. Losses of energy during transportation of whatever nature are at the expense of the supplying party.'

213. Article IV could be amended to reflect the condition that, if compensation is made in equivalent amounts of energy resources, this is to be based on caloric values.

214. Article VIII could be amended in such a way that the binding intergovernmental decisions are implemented by the owners and operators of the hydro-power facilities and by the relevant energy companies as executive bodies. UDC Energy is responsible for the management of interstate electricity transfers under this agreement. The BVO Syr Darya and UDC Energy are responsible for monitoring the execution of the intergovernmental decisions and reporting to the water, fuel and energy organisations.

215. An Article could be added specifying that at all times a minimum release of 100 m^3/s is guaranteed to maintain an adequate flow for sanitary purposes in the downstream river reaches.

8.5.3 Continuation of the 1998 Agreement with Major Modifications

216. The focus of the major modifications would be to agree on a long-term sustainable operating regime, e.g. for a five-year period.

217. Article II could be amended as follows:
"To ensure the agreed operating regimes, the water, fuel and energy organisations, headed by Vice-prime Ministers of the signatory countries, will agree on sustainable operating regimes of the hydro-technical facilities and reservoirs of the Naryn-Syr Darya Cascade, and on irrigation water releases for a period of five water management years.
The parties deem it necessary annually to coordinate and make decisions on the adjustment of water releases, production and transit of water diversions for irrigation by river reaches, electricity, and compensation for energy losses, on an equivalent basis, depending on the actual water stored in the reservoirs and flow forecasts for the next season. The annual coordination and decision-making on these adjustments will be by intergovernmental agreement by the water, fuel and energy organisations headed by the ministers and directors of these organisations, and subsequent approval by the Vice-prime Ministers."

218. Agreement on a longer-term sustainable operating regime has the advantage that all parties know what can be expected, but more importantly the variability in the natural flow can better be accommodated by carrying over to the next year any surpluses or shortages encountered in the current or previous year with the aim of maintaining the sustainable multiyear regulation of the storage reservoirs.

219. Consideration should be given to the inclusion of an article specifying that Kazakhstan and Uzbekistan would agree to pay a premium on the uniform tariff for the electricity transferred to those countries in the growing period, as partial and proportional payment for the operating and maintenance costs and as a service fee for maintaining the agreed long-term operating regime of the reservoirs in Kyrgyzstan. The premium would be agreed upon annually during the annual coordination and decision-making meeting described in Article II of the agreement.

220. An alternative to the payment of such a premium is to consider that the agreed uniform tariff policy based on an agreed fraction of world market prices for electricity reflects the cost of generation, including operation and maintenance costs. The drawback is that in that approach a premium to reflect the service fee for maintaining a certain regulating regime is not covered.

221. Besides the above essential changes, the amendments proposed under the first option would also figure under this second option.

8.5.4 Continuation of the 1998 Agreement with Structural Reform

222. The focus of a structural reform is that it should fit in the transition to free and open market conditions at a comparable level in all countries concerned. When such

conditions are met, a situation could arise leading to a dissociation of water management and energy exchanges by intergovernmental agreement.

223. The main idea is to elaborate the second option further in the sense that an existing regional interstate legal entity will be charged with the keeping of accounts of all volumes and values of energy flows between the parties concerned, and will manage a credit facility to be able to step in temporarily when one of the parties is occasionally and unintentionally not in a position to fulfil its obligations *vis a vis* another party.

224. In order to establish this mechanism, an international financing institution such as the World Bank or Asian Development Bank could be approached to provide and supervise the credit facility, which would be essential to ensure transparency of the operations of the interstate organisation to be charged with the accounting of the energy flows. The international financing institutions should be approached by the appropriate governmental or intergovernmental organisation to apply for their assistance in creating this mechanism.

225. In this option, the proposals for change made under the first and second options would apply as well.

8.5.5 Water and Energy Consortium

226. In Article VIII of the framework agreement of 1998, the establishment of the International Water and Energy Consortium and its executive body was foreseen. They would be charged with the implementation of the decisions taken on management of the Naryn Syr Darya Cascade. To date, draft texts on the mandate and functions of a Water and Energy Consortium are circulating between various organisations concerned. Formally speaking, the Water and Energy Consortium has not been established to date.

227. From a review of draft proposals by Kazakhstan and Kyrgyzstan on the Consortium, it is concluded that they do not describe the core of the matter on what would be managed by the Consortium and how it would do that. The texts are very general and would require major revisions to make it work. It is generally understood that a Water and Energy Consortium would act as a (commercial) executor of the annual intergovernmental agreements within the framework agreement of 1998. The idea seems to have support in Kazakhstan and Kyrgyzstan and from various international organisations.

228. It is doubtful whether a Water and Energy Consortium can be established under the present conditions: (i) yet another organisation would be created, (ii) the energy sectors in the four countries concerned are organised entirely differently from each other, from privately-owned companies in one country to fully State-controlled operations in another, (iii) laws and regulations governing the energy sectors in the countries differ, and it would be very difficult to establish a consortium that would be recognised legally by all countries and be empowered to operate effectively.

229. In conclusion, pursuing the establishment of a Water and Energy Consortium would be a long and difficult process, leaving the current problems basically unresolved.

9. REGIONAL WATER MANAGEMENT INSTITUTIONAL STRENGTHENING

9.1 Current Institutional Arrangements for Regional Water Management

230. The need for a regional mechanism for water resource management was recognised at an early stage after Independence. In October 1991, the five Ministers in charge of water resources agreed to maintain the procedures, rules and limitations that functioned under the former soviet system until new regional structures were developed, and on 18 February 1992 in Almaty signed an Agreement which established an Interstate Commission for Water Coordination (ICWC). This agreement was confirmed by the Heads of State of the five governments in March 1993. The main ICWC functions are to:

- determine water management policy for the region,
- determine limits on water consumption annually in the Basin for each republic and the region and as a whole,
- allocate available water resources, including water for the Aral Sea,
- schedule water reservoir operations.
- determine the future program for water supply and measures to implement the program,
- coordinate construction of major works.

231. The ICWC comprises officials from the water resources agencies of the five member countries. Every three months ICWC determines the operational modes of the Naryn-Syr Darya Cascade and the water shares of the counties for the vegetation and non-vegetation periods, subject to forecast water availability. Decisions of the ICWC are supported by its Secretariat located in Khodjent, and allocation of water is implemented by the basin water management organisations, the Syr Darya and Amu Darya Basin Water Associations (BVOs). Scientific and information support at the interstate level is provided by the Scientific Information Centre (SIC) of the ICWC.

232. The International Fund for saving the Aral Sea (IFAS) was established by the Heads of State in January 1993, and in July of that year they approved the institutional arrangements outlined in Figure 1. According to the decision of the Heads of State, IFAS is mainly a financial body. Importantly, however, the IFAS board consists of the deputy prime ministers and it functions through an Executive Committee (EC-IFAS), which comprises two representatives from each country, and two interstate commissions concerned with the coordination of:

- water-related activities (ICWC),
- ecological, socio-economic and scientific-technical collaboration (CSD).

9.2 Current Deficiencies in Regional Water Management Institutions

233. The structure of the ICWC is illustrated in Figure 1. The situation is that the ICWC, composed of ministers and deputy ministers responsible for water resources in the various States, has served well. It has good, practical experience and proven ability in working on a regional scale and consolidating its activities in all five countries. However, whilst the ICWC determines the operational mode of the reservoirs and of the

diversion structures in consultation with the other sectors, the members are not empowered to represent the interests of the other sectors. More importantly, ICWC has no power to enforce its decisions on allocations and reservoir operations and diversions. The fact that there are a number of problems that have not been solved under the existing arrangements makes it clear that considerable strengthening and restructuring of the current institutional framework is needed.

EXISTING ARAL SEA BASIN (IFAS) INSTITUTIONAL ARRANGEMENTS

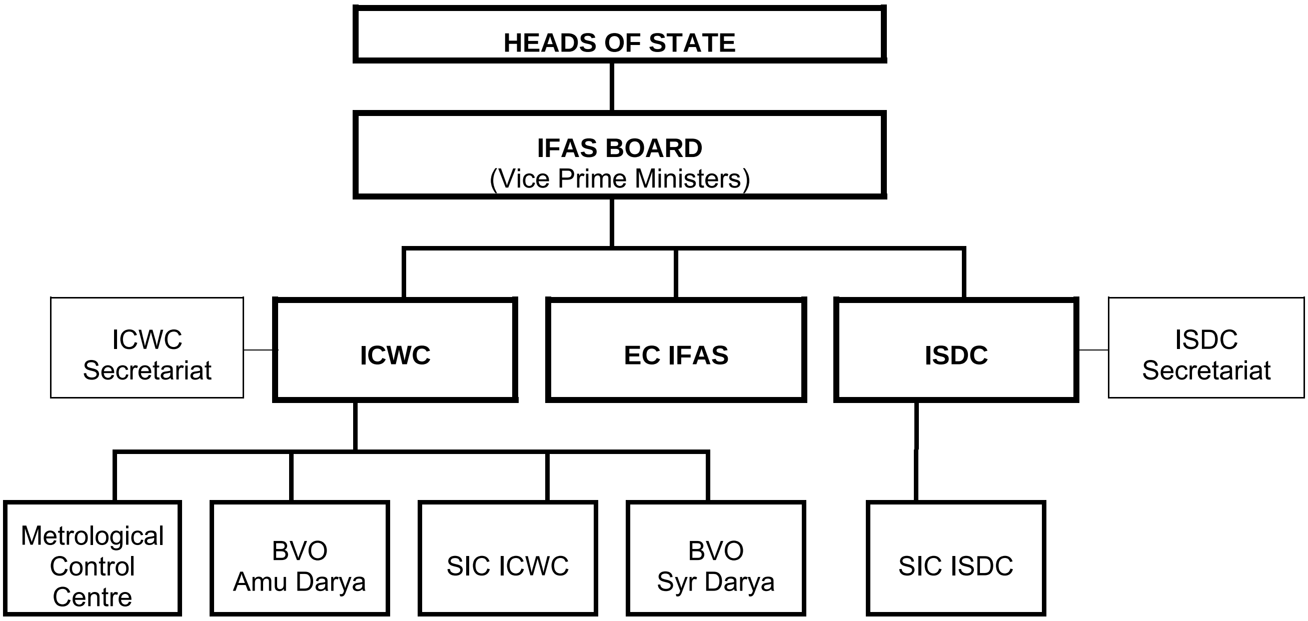

Figure 1

234. The SIC-ICWC effectively operates as a scientific and technical information exchange, water resources policy development, and planning agency. BVOs do not operate any of the key river reservoirs and are not able to enforce compliance with any allocation or reservoir operation decisions, and they operate as monitoring organisations.

235. It is understood that water resources development projects being implemented throughout the Aral Sea Basin are facing complications because of interstate issues over access to water resources or water infrastructure. None of these projects addresses the central issue - the absence of an effective regional focal point or body with the political mandate and competence to accommodate the differing positions and sometimes conflicting interests of the various States, sectors and agencies. The fact is, there is no single organisation in which the key sectors having primary responsibility for water resources management and development are represented. Ideally, resolutions relating to water resources ought to be taken by a regional body that represents and takes into account all these interests, and that has the power to implement those resolutions.

236. A major shortcoming of the existing organisations is that their sectoral compositions differ, and resolutions are taken that impact on transboundary water resources management in which only part of the key water and energy sectors are represented. It may be that, at times, such resolutions should not have been implemented, because the relevant sectors were not involved in the decision-making process and the decisions affected millions of people. An example is the operation of Toktogul reservoir, which is carried out by the energy sector of Kyrgyzstan. In this case, water consumption limits as well as reservoir operations depend on annual agreements. However, the operation of Toktogul is effected outside of the ICWC and the BVO has no authority to make corrections to its operation. According to the 1998 Agreement among the Syr Darya riparians, formation of yet another organisation (Water and Enegy Consortium) for the regulation of the Syr Darya reservoirs was contemplated at that time, but has been established till date.

9.3 Institutional Strengthening

237. From the legal and organisational point of view the existing institutional relationship, developed under the framework of the Decision of the Heads of States about the status of the IFAS and its organisations (Ashgabat, April 8-9, 1999) have sufficient potential to satisfy institutional needs in the coming future. The main efforts in this field have to focus on practical implementation and effectiveness of that Decision.

238. It is suggested that there is a need to strengthen the IFAS arrangements by having representation of the energy sector in the IFAS decision-making process. The republics understand that only through cooperation will mutually beneficial use and protection of the available resources be achieved, and the Heads of State have confirmed in various declarations and agreements (such as the agreement confirming the status of IFAS) that the problems in the basin will be resolved jointly and fraternally, which provides an excellent starting point.

239. From a strategic perspective, it is proposed that in the short term effectively strengthening the existing IFAS and ICWC arrangements, by increasing its capacity, is the way forward. The IFAS Board, composed of Vice-prime Ministers from each of the five States, is at the appropriate high level for decision-making. However, IFAS is basically a finance body and does not ensure common regional environmental policy to full extent.

240. ICWC has a proven ability at working on a regional scale, but in order to enhance its power it is proposed that the IFAS Board Meeting would be held once or twice per year under the leadership of Vice-prime Ministers from the five states and with representation of all relevant organisations. The function of the IFAS Board Meeting is to make key strategic decisions from a regional water resource management perspective, on the basis of integrated policy advice from ICWC and the energy and environment sectors. The suggested arrangement is shown in Figure 2.

PROPOSED SHORT-TERM ARAL SEA BASIN INSTITUTIONAL ARRANGEMENTS

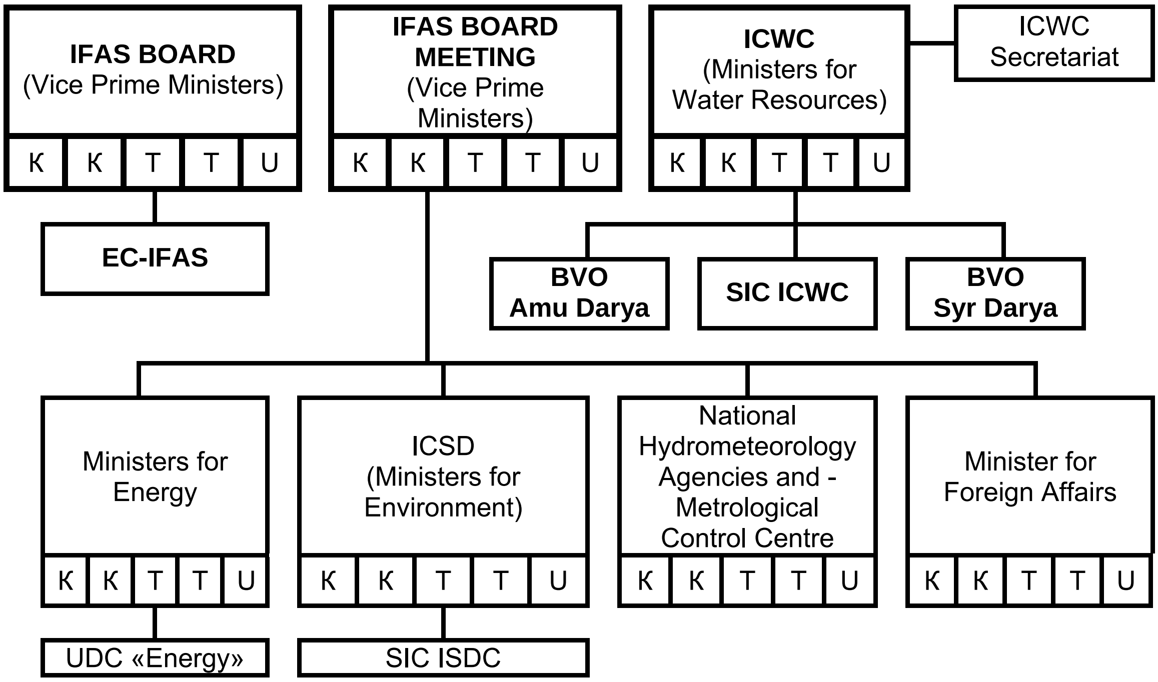

Figure 2

241. Effectively, the proposal suggests that the IFAS arrangements, comprising the water (ICWC) and environment (CSD) sectors from each of the five States, be strengthened to also include participation of the energy sector in the IFAS Board Meeting.

242. In the short term it is expected that the day-to-day distribution of water in the Amu Darya and Syr Darya will continue to be overseen by the two BVOs. However, it is suggested that their responsibilities should possibly be broadened to include the operational responsibility for all the primary offtakes on the transboundary rivers and also water quality management. The necessary financial and operation arrangements are still under study and the BVOs are being consulted on these issues.

243. Consideration should be given to rotation between the countries of the leadership and key staff of the regional organisations under the ICWC.

244. An outline for an alternative long-term perspective for institutional arrangements is described in Appendix 5.

10. FUTURE DIRECTIONS

10.1 Introduction

245. In this chapter are presented the main directions for WEMP-A1 and a preliminary proposal for an outline of the policy, strategy and related actions underlying the regional water and salt management plan. The regional water and salt management plan will be finalised in the remainder of Phase VI in consultation with the National Working Groups.

10.2 Future directions for WEMP-A1

246. The result of Phase VI as described in the Terms of Reference must form for the client a useful basis for the subsequent political process of further harmonization and decision making between the five Central Asian republics during Phase VII. This means that the Draft National Policy and Action Plan (Report D-NR2) and the Draft Regional Policy and Action Plan (Report D-RR3) – which will be submitted by the end of Phase VI - will offer practical proposals for rational water use, increased water productivity, and mechanisms for mutually beneficial interstate cooperation. It also means that the main directions will have the support of the five Central Asian countries.

247. In order to facilitate this process the IC/RWG will continue to seek support from the ICWC members. Furthermore the IC/RWG will give guidelines to the NWGs on enhancement of their Draft National Plans in order to reach consolidated regional policies, strategies and actions plans for water and salt management. Country specific opportunities will be developed within the regional framework for co-operation.

10.3 Aim of the Regional Plan

248. The aim of the regional plan will be to establish policies and strategies within a Basin-wide framework that will permit the sustainable use of the water resources of the Aral Sea Basin over the long term.

10.4 Basic Assumptions for Future Regional Development

249. A basic assumption made in this project is that all five Central Asian countries are committed to the eventual adoption of a free market system, with the abolition of the system of 'State orders' and government control on commodity prices in the agricultural and energy sectors where these still exist. These will be critical in any strategy, because unless farmers: (i) receive adequate prices for their produce, and (ii) have the freedom to grow the most profitable crops, there will be no incentive for them to improve their agricultural, and particularly, water management practices. The lack of any incentive for farmers to improve their on-farm water management practices is considered the key reason for the generally low standards of management that currently prevail. It is self-evident that regional and national management plans and action programs for water and salt management must be practicable and financially viable.

10.5 Draft Regional Water and Salt Management Plan

10.5.1 Introduction

250. In this Section the fundaments for the regional plan are presented in the following order: the main water related issues, the policy to overcome the mentioned problems, the strategies to reach the objectives as stated in the policy and the more detailed actions as part of the different strategies.

10.5.2 Issues

251. The main water related issues on which a basin-wide policy is to be based are presented below:

Aral Sea Basin overall

- **With reasonable standards of management**, the water resources of the Aral Sea Basin are sufficient to meet current and future irrigation requirements and provide an adequate volume for environmental purposes in the lower reaches of the rivers and the delta areas.
- Currently much of the water diverted for irrigation purposes is wasted, either entering the groundwater by seepage or discharging directly from the canals into the drainage system, where, in the downstream systems, almost half of the drainage water is lost permanently in desert sinks.
- In brief, the generally low standard of water management is the main water-related problem in the Aral Sea Basin. High river water salinity is not a significant problem for irrigated agriculture when the water is used for short periods (1-2 years)..

On-farm water management

- Most of the losses take place on the farms – on average over the Aral Sea Basin over 50% of the water supplied to farm boundaries does not reach the field.
- The losses are of an operational nature, i.e. due to deficiencies in management, although seepage and similar losses to the groundwater are also very significant.
- The reasons for the low standards of on-farm water management include a lack of:
  - incentives for farmers to improve their standards of management, including service charges for irrigation water supply,
  - knowledge on the part of the farmers as to how to improve, once the incentives are there,
  - specialist advice and input to the irrigation process,
  - the means to achieve improvement, particularly water measurement equipment,
  - up-to-date and good quality technical equipment.

Shallow watertables

- The operational and seepage losses in the water system have caused, and now maintain, shallow watertable conditions over a large proportion of the irrigated area in the downstream countries.
- The shallow watertables cause costs and losses in several ways, including soil salinity-related crop yield losses, machinery-related costs, and the costs of leaching. Crop yield losses occur particularly in the delta, even though cotton and wheat are relatively salt tolerant crops.
- Much of the losses are due to uneven field grading, which results in bare patches in fields caused by high soil salinity levels or under-irrigation e.g. due to high spots.

Water salinity levels

- Economic losses caused by river water salinity are relatively small for irrigated agriculture, and are likely to remain so in future.
- Nevertheless, peak river water salinity levels in the downstream areas are at times almost twice the permissible standard in Central Asia for drinking and domestic water of 1g/l. Thus, the reduction of salinity levels to below that level is an important objective.
- Groundwater salinity levels in the downstream areas are in general much higher than permissible drinking water standards.

Agricultural production

- Agricultural production levels are low due to:

– inappropriate farming and irrigation techniques, including land preparation and weeding practices,
– insufficient inputs such as fertilisers and herbicides, and inadequate inputs such as poor quality seeds,
– deteriorated infrastructure,
– lack of knowledge on the part of the farmers and farm managers,
– lack of incentives in some countries under the system of State control of production and marketing.

Environmental issues

- Although the large-scale irrigation and hydropower developments in the Basin have resulted in a big increase in agricultural and energy production, they have led to many problems. These include a decline in the Aral Sea level, changes in groundwater levels, salinization, pollution, reduction in environmental flows, wildlife habitat destruction, erosion and sedimentation.
- The lake systems and wetlands in the delta areas are important to local people as sources of fish, reeds and fur animals. They also provide valuable habitat for many species of mammals and wildfowl, with some areas being of international importance.
- An average environmental flow totalling 19 km^3 per year in the two rivers is needed to maintain reasonable conditions in the delta wetlands and lakes and in the Northern Aral Sea. This represents an increase of 7 km^3 per year, or about 60%, above the current level.

- Provision of additional water to maintain reasonable salinity levels in other segments of the Aral Sea is not considered a realistic option in the short to medium term. A high level policy decision would be required by the States on the issue of saving the western part of the Aral Sea.

Institutional Issues

- Currently, there is no regional focal point or body with the political mandate and competence to accommodate the differing positions and sometimes conflicting interests of the various States, sectors and agencies. The ICWC is not empowered to represent the interests of the energy and environment sectors, and it has no power to enforce its decisions on allocations and reservoir operations and diversions.
- BVOs do not operate any of the key storage reservoirs and are not able to enforce compliance with any allocation or reservoir operation decisions, and with respect to the reservoirs they operate basically as monitoring organisations.

10.5.3 Policies

252. The main policies or principles underlying the Water and Salt Management Strategy for the Aral Sea Basin are that:

- The water resources of the Aral Sea Basin are to be managed in a way that maximises water productivity, and will enable irrigated agriculture to be carried out in a sustainable manner in the long term.
- Activities in the Basin should be carried out in an environmentally sustainable manner, including the provision of adequate volumes of water for environmental purposes in the lower reaches of the rivers and the delta areas.
- The water quality (particularly salinity) regime throughout the Aral Sea Basin should be such as to allow irrigation, environment and other uses of water to be undertaken in a sustainable manner in the long term.

10.5.4 Strategy

253. Improved management at various levels is seen as the central approach for the basin-wide water and salt management strategies. Around it are various other measures relating to organisational, operational and technical practices.

254. The basic strategy involves the following actions:

- Organisational

– Strengthening of the ICWC to include representation from the water, energy and environment sectors, and providing it with the political backing and legislative mandate to enforce its decisions.

– Strengthening of other involved organisations like BVOs and (scientific) institutes.

– Improvement of the management of the Naryn Syr Darya cascade through establishment of a long term sustainable operating regime and better mechanisms for the implementation of intergovernmental agreements.

- Relaxing control on agriculture by giving farmers more freedom to grow the most profitable crops and enable adequate prices for their produce.
- Improving agricultural education and related additional training programs for specialists.

• Operational

- Improving irrigation and agricultural practices, with the addition of specialist personnel on farms.
- Improving conveyance and distribution practices in the irrigation systems.
- Improving water supply practices to the requirements of environmental and agricultural demand management.
- Improving and accelerating the interaction between the hydro-power systems and downstream water demand systems.

• Technical

- Rehabilitation and reconstruction of irrigation and drainage infrastructure in order to increase efficiencies and productivity.
- Laser land levelling.
- Assistance on and optimisation of in-field irrigation application and leaching practices in order to minimise water losses and maintain a sufficient water quality with respect to salinity.
- Rehabilitation, reconstruction and new installation of monitoring devices for water flows, water quality and groundwater characteristics.

APPENDIX 1

OPTIMISATION AND SIMULATION STUDIES – DATA AND RESULTS

APPENDIX 2

WATER QUALITY STANDARDS

CURRENT WATER STANDARDS IN CENTRAL ASIAN COUNTRIES FOR DIFFERENT TYPES OF USE FROM SURFACE AND GROUND WATER SOURCES

Kazakhstan

1. Sanitary-epidemiological service of the Health Agency set up the standards of water quality upon the agreement with the Ministry of Natural Resources and Nature Protection. As the process of preparing normative documents on water quality takes a long time and requires large scientific research works of sanitary –hygienic character, activities in this sphere has not been changed yet. They are still focused mainly on observation and improvement of former Soviet Union normative-methodological statements and adaptation of newly approved Russian methodological documents to Kazakhstan conditions.

2. The criteria of assessing surface water pollution in Kazakhstan are maximum allowable concentrations (MAC) of polluting substances, which are accepted on the basis of **SanR&C 4630-88 "Sanitary Regulations and Codes on Surface Water Protection".** These regulations were approved by the Ministry of Health of the USSR (04.06.1988). Nowadays, they operate in the territory of the Republic of Kazakhstan according to the order of the Chief of Sanitary-Epidemiological Service Department of the Ministry of Health of the RoK No.408 of 18.08.1997, and additional list No.3 of MAC for water of fish industry water bodies (No.12-04-11 from 27.12.1991).

3. Hygienic classification of water objects is performed upon the degree of pollution, the basis of which is the leading principle of normative documents of sanitary legislation. The main objective of hygienic classification is to prevent negative impact of chemical and microbe factors of water on population. The first and the second category of water users are established by surface water sanitary rules and norms of protection SanR&C 4630-88 subdivides water users into two categories: 1 category (household/drinking) and 2 category (public). They are classified by pollution indices: 0- without restrictions, 1 – moderate degree, 2 – a basin is not suitable for all kinds of water use, 3 – typical for water basins with high level of pollution and even short-term use of this water can have negative consequences for human health.

4. Normative documents regulating drinking water quality are Russian normatives, which are allowed for application as the most corresponding ones to the conditions of Kazakhstan. The following documents are the main of them:

- "Drinking water. Hygienic demands to the quality of water of centralized drinking water supply systems. Quality control". Sanitary regulations and codes SanR&C 2.1.4.559-96, the State Committee of Sanitary and Epidemiological Inspection (Goskomsanepidemnadzor) of Russia, Moscow, 1996;
- Methodical Instructions (MI) on introduction and observation of Sanitary Regulations and Codes SanR&C 2.1.4.559-96 "Drinking water", MI 2.1.4.682-97, health Ministry of Russia, Moscow, 1997;

- "Zones of sanitary protection of household/drinking water supply sources and water-pipes, SanR&C 2.1.4.027-95, Gossanepidemnadzor of Russia, Moscow, 1995.

5. Nowadays in Kazakhstan there are no special officially accepted norms for irrigation water, but there are a number of methodologies for such determination. To assess irrigation water quality it is expedient to use ecological, agronomic, technical and economic criteria. Irrigation water composition and characteristics, mainly temperature, pH, salt composition, ions' ratio, macro and microelements influence on breakup of humus, microbiological, biochemical and physical and chemical processes that predetermine soil fertility. At the same time, irrigation water quality influences norms of water requirements, yield and quality of agricultural produce. The worked out regulating principles could serve as a basis for creation of irrigation water quality standards' bank and also could be used for the development of the state standard.

Kyrgyzstan

6. Legal relationship in the sphere of household/drinking water supply to the population and quality control of supplied drinking water are set up by the Laws of the Kyrgyz Republic "On Environmental Protection", "On Depths", "On Drinking Water", as well as by the state standards and sanitary rules and norms.

7. On the territory of Kyrgyzstan, "Rules on protection of surface water in KR" that were approved by the State Nature Committee of KR in 1993 and registered by the Ministry of Justice of KR (index 136 of 13.10.1993) are applied to control quality of water in surface water objects. These rules regulate export of all wastewater, including municipal, domestic, industrial, rain and snow waters and etc. to the streams and water reservoirs.

8. The rules also regulate different types of economic activities that could or render injurious effect on surface water's state.

9. The mentioned rules apply to all water streams and water bodies of KR, including lakes and reservoirs.

10. Measurement of water quality in surface water bodies includes definition of aggregate allowed values of indices of its quality and characteristics, which ensure people's health, favorable water use conditions and ecological sustainability of water body.

11. The "Rules" set up water quality norms for water bodies and streams supplying water for household/drinking, communal-general and fish industry purposes, as well as quality norms for irrigation water.

12. Maximum allowable concentrations (MAC) of standardized substances in water of water objects are set up on the base of Sanitary Regulations and Codes (SanR&C No.4630-88). Environmental protection departments control observation of the demands set in these "Rules". Extracts from the mentioned "Rules" regulating MAC of main contaminants typical for KR are given further in the Table.

13. Drinking water quality is regulated by the following standards: GOST 2874-82 "Drinking Water"; GOST 2761-84 "Sources of centralized household/drinking water

supply. Hygienic, engineering requirements and choice laws". SanR&C 4630-88 "Sanitary regulations and codes on protection of surface waters from pollution".

14. By many of its indices GOST 2874-82 "Drinking water" does not differ from the standards of European countries and the last recommendations of World Health Organization (WHO). GOST 2761-84 determines suitability of water object for drinking water supply and sets standard demands to quality of water in water supply sources. According to standard demands, water should undergo treatment and decontamination (disinfection) prior to supply to water supply network.

Extract of maximum allowable concentration (MAC) of normalized substances in water of water objects used for household/drinking, municipal and fishery water supply

Denomination of substance	***MAC, mg/l***	
	For reservoirs used for household/drinking and municipal water supply	For reservoirs used for fishery
Oxygen biochemical demand (BOD)	6,0	3,0
Ammonia	2,0	0,05
Vanadium	0,1	0,001
Tungsten	0,05	0,0008
Ferro	0,5	0,05
Cadmium	0,001	0,005
Cobalt	0,1	0,01
Manganese	0,1	0,01
Copper	1,0	0,001
Molybdenum	0,25	0,0004
Oil products	0,3	0,05
Nickel	0,1	0,01
Nitrates	10,0	0,02
Nitrites	1,0	10,0
Sulfates	500	100
Chlorides	350	300

Tadjikistan

15. Water quality is characterized by its composition and characteristics, which determine its suitability for certain categories of water use and consumption. Water quality criteria are features, on the base of which water quality is rated proceeding from the categories of water use and consumption. Maximum allowable concentration (MAC) of harmful substances in water worked out by the Health Ministry of the former USSR are still in force in our republic. MAC is the main hygienic standard, which was taken as a base for the current water-sanitary code. MAC standards (mg/l) have been set for all possible substances entering water bodies. Waste water, which at controlled sites display increased MAC, are prohibited to be disposed to water reservoirs.

16. Biochemical oxygen demand (BOD) indicates oxygen content in water required for oxidation of contaminants present in the water, mainly organic substances. For domestic waste waters oxygen demand is rather stable and depends on water use rate per head. For industrial waste waters BOD varies within a very wide range. pH

value shows concentration of hydrogen ions in water and conditions its acidity and alkalinity. At sites of public-domestic water use, pH value should not exceed 6,5-8,5.

17. Organoleptic water feature characterize scent, flavor (taste) and floating admixtures having unfavorable impact on people. These features are assessed in numbers (points).

18. Sanitary-hygienic standards for evaluating quality of water used for household/drinking and public-domestic purposes include the following factors: suspended substances, floating admixtures, scents and tastes, color and temperature, pH value, water salinity, dissolved oxygen, biochemical oxygen demand (BOD), pathogenic organisms and toxic agents.

19. General requirements to composition and characteristics of water used for household/drinking water supply are given in the Table below.

General demands to water composition and quality in water objects used for household/drinking water supply

Index	**Demands and water quality index in water objects**
Suspended substances	Upon discharge of waste water content of suspended substances should not increase by more than 0,25 mg/l
Floating admixtures	Water should not be covered by lamina of oil products and should not contain other admixtures
Scents and flavor	Their intensity should not exceed 2 numbers (points). Water should not have unwanted scents, and meat or fish flavor.
Color	It should not appear in 20-cm column of water.
Temperature	It should not increase by more than 3 degree when compared with monthly average for the last 10 years.
pH value	Within 6,5 - 8,5
Water salinity	By solid residue it should not exceed 1000 mg/l, including chlorides 350 mg/l and sulfates 500 mg/l.
Soluble oxygen	Not less than 4 mg/l at any time of the year in a sample taken prior to 12 a.m.
Oxygen biochemical demand (BOD)	At temperature of 20ºC it should not exceed 3 mg/l.
Pathogenic organisms	As to the content of intestinal bacillus bacteria, number of microorganisms in one mm^3: If water is not planned to be treated, their number should not exceed 100, if water is planned to be treated, their number before treatment should not exceed 10000.
Toxic agents	Not exceeding MAC.

20. The character of surface river water quality is increased turbidity, especially during spring and autumn periods, which is conditioned by spring high water and rain floods. Data on turbidity and as a whole on hydrochemical (aqueous) regime of rivers are published by Hydremeteorological Service of the Republic of Tadjikistan by separate edition "Annual data on surface water quality" being a part of the state Water Cadastre.

21. Salinity as to the content of dissolved salts is the main factor indicating whether water is suitable for drinking or not. The following suitability gradations are taken as current standards indicating whether surface water are suitable for drinking or not:

- 0-600 mg/l - good quality drinking water;
- 600 - 1000 mg/l - satisfactory quality drinking water;
- 1 - 1 ,5 g/l - water acceptable for drinking;
- 1,5 - 2,5 g/l, - water acceptable for drinking on necessity;
- 2,5 - 4,0 g/l, - water acceptable for drinking in extreme cases;
- more than 4 g/l, - not suitable for drinking.

22. Quality standards of water used for centralized water supply are regulated by **the State Standard (GOST 2874-82 - Drinking water)** and **Regulations on protection of surface waters from pollution**. According to the above given gradation, water in majority of Tadjikistan rivers are of good drinking quality during the whole year. In low-flow period water drinking quality in some rivers decreases owing to increase of water salinity.

Turkmenistan

23. Water quality standards were set by the values of maximum allowable concentrations (MAC) of contaminants. MAC for sources of drinking water supply and fish-breeding reservoirs are given in the Table below.

Contaminants' maximum allowable concentration (MAC) values for drinking and fishery water supply

No.	Denomination	Reservoirs for sanitary and domestic needs (use)	Fish-producing reservoirs
1	2	3	4
I. Gas composition main components, mg/l			
1	pH values	6,5-8,5	-
2	Hydrocarbonate, HCO_3	-	-
3	Sulfates, SO_4	500	100
4	Chlorides, Cl	350	300
5	Calcium, Ca	180	180
6	Magnesium, Mg	40	40
7	Sodium + potassium, Na +K	120+50	120+50
8	Ion totals,	1000	-
9	Total hardness, mg-eqv/l	7,0	-
II. Organic substances, including contaminants, mg/l			
1	Oil products	0,3	0,05
2	Synthetic Surface Active Substances (SSAS) - (detergents))	0,5	0,1
3	Phenols (volatile)	0,001	0,001
4	Bichromatic oxidability	15,0	-
5	BOD_5,mgO_2/l	Not more than 3,0	-
III. Biogenic components and contaminants of inorganic origin, mg/l			
1	Ammonia nitrogen	2,0	0,5(0,39N)
2	Nitrite nitrogen	1.0(0,3N)	0,08(0,02N)
3	Nitrate nitrogen	44 (10N)	40(9,1N)
4	Aggregated phosphorous	3,5	3,5
5	Aggregated Ferro	0,5	-
6	Silicon	10	10
7	Copper	1,0	0,001
8	Zinc	1,0	0,01
9	Nickel	0,1	0,01
10	Plumbum (lead)	0,03	absent
11	Mercury	0,0005	absent
IV. Pesticides, mkg/l			
1	DDT (trichloroethane – $C_{14}H_9Cl_5$)	0,2	absent
2	α-hexachloran	0,1	absent

CHEMICAL, PHYSICAL, BACTERIOLOGICAL, HYDRO BIOLOGICAL AND TOXIC WATER FACTORS

Pollution level	Soluble oxygen, mg/l		BOD_5 Mg/l	Oxidability, mg O_2/l	Ammonia nitrogen, mg/l	Suspended substances, mg/l	Clarity		Scent (smell), numbers (points)	Oil, mg/l	pH	Coli-titre	Biological factor, PBF, %	Ratio of substance MAC to water MAC
	In summer	In winter					By Sekki, m	By Snellend, cm						
Very pure	9	13-14	0.5-1.0	1	0.05	1-3	>2	>30	1	0	6.5-8.5	100-10	0 - 5	0
Pure	8	11-12	1.1-1.9	2	0.10	4-10	2-1	30-20	2	0.1-0.2	6.5-8.5	1-10	6 - 10	0.1-0.9
Moderately polluted	6-7	9-10	2.0-2.9	3	0.20-0.30	11-19	1-0.3	19-3	3	0,3	6-9	<0.05-1	11 - 20	1.0-5.9
Polluted	4-5	4-5	3.0-3.9	4	0.40-1.00	20-50	0.3-0.1	2-1	4	1	5-6 9-10	<0.005-0.05	21 - 60	6.0-10,9
Muddy	2-3	0,5	4.0-10	5-15	1.10-3.00	51-100	0.1-0.02	1.0-1.5	5	2	5-6 9-10	<0.05-0.001	61 - 99	11.0-20.0
Very muddy	0	0	>10	>15	>3	>100	<0.02	<0.5	5	3	2-4 11-13	<0.001	100	20

Pollution biological factor (PBF) = B/(A+B) % - this is biological factor showing ratio of one-cellular organisms, which do not contain chlorophyll (B) to the total number of organisms, including those, which contain chlorophyll (A).

POLLUTION IMPACT ON THE POSSIBILITY TO USE THE WATER

Pollution level	Type of use						
	Household/drinking, food industry	Swimming. sports	Fish industry, fish-breeding	Industrial use		For washing of transport ships, port facilities	Agricultural irrigation
				For technological purposes	Far water rotation systems		
Very pure	Suitable	Suitable	Suitable	Suitable	Suitable	Suitable	Suitable
Pure	Suitable	Suitable	Suitable	Suitable	Suitable	Suitable	Suitable
Moderately polluted	Suitable after treatment	Suitable after treatment	Suitable for certain fish species	Suitable after treatment	Suitable after treatment	With difficulty	Suitable with restrictions
Polluted	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Suitable after treatment	With difficulty	Suitable with restrictions
Muddy	Unsuitable	Absolutely unsuitable	Unsuitable	Unsuitable	Suitable after treatment	Suitable after treatment	Suitable with restrictions
Very muddy	Unsuitable	Absolutely unsuitable	Unsuitable	Unsuitable	Suitable after treatment	Suitable after treatment	Suitable in individual cases

Uzbekistan

24. Water quality standards that are used in Uzbekistan nowadays are given in the following Table (Data of the State Nature Protection Committee of the Republic of Uzbekistan):

Substance	Maximum allowable concentration (mg/l)	
	Waste water treatment	Fishing
Biological oxygen demand (BOD_5)	500	3
Chemical oxygen (COD)	500	30
PH	6-9	6,5-8,5
Oil products	5	0,05
Phenol	5	0,001
Cadmium	5	0,005
Ferro	5	0,5
Copper	0,5	0,01
Nickel	0,5	0,01
Tin	0,5	0,03
Chromium	0,1	0,001
Zinc	1	0,01
Arsenic	0,1	0,05
Mercury	0,1	0,005
Cyanide		0,05
Nitrogen (total)	30	0,05
Ammonium nitrate	100	0,39
Nitrite	100	0,08
Nitrate	100	0,1
Chlorine		нет
Detergents		0,1

25. Sources for centralized water supply are chosen on the base of the State Standard of Uzbekistan “Sources for centralized household/drinking water supply; hygienic, technical requirements and choice law”, which was given effect in 2002. The Standard set forth hygienic and sanitary-technical requirements to the chosen sources of centralized water supply, as well as choice laws in the interests of population’s health.

Classification of water quality index
of underground water supply sources by classes

Index denomination	Water quality index by classes		
	1	2	3
Turbidity, mg/l not more than	1,5	1,5	10,0
Color, points, not more than	20	20	30
Hydrogen, index (pH)	6-9	6-9	6-9
Ferro (Fe), mg/l, not more than	0,3	5,0	10,0
Manganese (Mn), mg/l, not more than	0,1	1,0	2,0
Hydrogen sulfide (H_2S), mg/l, not more than	absent	Absent	3,0
Fluorine (F), mg/l, not more than	0,7	0,7	5,0
Permanganate oxidability, mg O_2 /l, not more than	2,0	5,0	10,0
Number of intestinal bacillus bacteria in 1 liter, not more than	3	100	1000

Classification of water quality index of
surface water supply sources by classes

Index denomination	Water quality index by classes		
	1	2	3
Turbidity, mg/l not more than	20	1500	10000
Color, points, not more than	30	50	100
Scents, points, not more than	2	3	4
Hydrogen, index (pH)	6,5-8,5	6,5-8,5	6,5-8,5
Ferro (Fe), mg/l, not more than	0,3	1,0	3,0
Manganese (Mn), mg/l, not more than	0,1	1,0	2,0
Fluorine (F), mg/l, not more than	0,7	0,7	5,0
Permanganate oxidability, mg O_2 /l, not more than	7,0	15,0	20,0
BOD total in mgO_2/l, not more than	3,0	5,0	7,0
Number of lactose-positive intestinal bacillus in 1 liter not more than	1000	10000	50000

26. The State Standard of Uzbekistan “Drinking water. Hygienic requirements and quality control”, which was also put into effect in 2002, also applies to drinking water supplied by centralized systems of household/drinking water supply, as well as to water supplied by centralized systems, which supply water simultaneously for household/drinking and technical needs. This Standard sets forth composition of controlled indices and their correspondence to the set requirements in the process of drinking water production and supply to water users.

Water quality international standards for different types of water use

Irrigation water quality

Practice of water quality assessment used in USA

27. If total salinity of water, which is used for irrigation, is less than 500 mg/l, salinization does not occur until groundwater level rises close to the original ground. Without adequate dilution by precipitation or fresh water from other sources, water with total salinity of about 5 g/l usually is hardly suitable for irrigation. As salinity increase water value and quality decreases. Classification of irrigation water by its salinity, which is used in USA, is given in the Table below:

Water quality and its possible use	Total salinity Mg/l
Water, which does not have negative impact on crop productivity	500
Water, application of which could have negative impact on productivity of agricultural crops characterized by low salt-resistance	500-1000
Water, application of which could have negative impact on productivity of many agricultural crops. This water should be used carefully.	1000-2000
Water that could be used for irrigation of salt-resistant crops on permeable soils. This water should be used carefully.	2000-5000

Quality of irrigation water by FAO classification (1985)

Irrigation potential problem	**Unit**	**Usage restriction level**		
		None	**From slight to moderate**	**Usage is stopped**
Salinity (influences development of plants):				
ECw, or	DS/m	<0.7	0.7-3.0	>3.0
TDS	mg/l	<450	450-2000	>2000
Infiltration (speed of water infiltration into soil influences its accessibility to plant)				
Is estimated using Ecw and SAR (together):				
at SAR equal to:				
from 0 to 3 Ecw=		>0.7	0.7-0.2	<0.2
from 3 to 6		1.2	1.2-0.3	0.3
from 6 to 12		1.9	1.9-0.5	0.5
from 12 to 20		2.9	2.9-1.3	1.3
from 20 to 40		5	5.0-2.9	2.9
Especially toxic ions (influences crop's sensitivity):				
Sodium (Na)				
Surface irrigation	SAR	<3	3-9	>9
Overhead irrigation	meqv/l	<3	<3	
Chlorine (Cl)				
Surface irrigation	meqv/l	<4	4-10	>10
Overhead irrigation	meqv/l	<3	>3	
Boron (B)		<0.7	0.7-3.0	>3
Additional impacts (influence sensitive crops):				
Nitrates (NO_3N)	mg/l	<5	5-30	>30
Hydrocarbonate (HCO_3) (only upon overhead irrigation)	meqv/l	<1.5	1.5-8.5	>8.5
pH		normal range	6,5-8,4	

Drinking water quality

28. Drinking water quality international standards according to the standards of Environmental Protection Agency (EPA), USA, and World Health Organization (WHO) are given in the Table below:

Substance	**Allowable concentration (mg/l)**	
	EPA, USA	**WHO**
PH	6,5-8,5	6,5-8,5
Cadmium	0,01	0,005
Ferro	0,3	0,3
Copper	1	1
Chrome	0,05	0,05
Zinc	5	5
Arsenic	0,05	0,05
Mercury	0,002	0,001
Plumbum	0,05	
Nitrates	10	10
Chlorine	250	250

APPENDIX 3

REGIONAL WORKING GROUP STUDIES

Introduction

1. This appendix deals with the results of a number of studies carried out by the Regional Working Group. They include:

- Regional optimization studies of the use of water for irrigation and energy generation, and of cropping patterns.
- Regional water balances
- Local and planning zone salt balances.
- Economic evaluation of options for irrigation improvement, including:
  - Rehabilitation of main, inter-farm and on-farm irrigation and drainage infrastructure,
  - Improving traditional irrigation practices,
  - Laser land levelling.

Optimisation Studies

<u>Model</u>

2. The optimisation studies were undertaken using the ASBOM model, which combines technical, economic, environmental and agronomic aspects throughout the Aral Sea Basin into a coherent framework. The model comprises interconnected national modules for each country, each consisting of a Water Network and an Energy Network, so that the interrelationship between water releases and energy generation can be taken into account.

3. The model is a useful tool, now and for future use, for evaluating at national and regional levels the implications of various strategy options and measures, and different water allocation mechanisms and rules. The models can be used to test any development and management scenario that interested parties may wish to have analysed. For example, while in these studies the water allocation limits for each country have been applied according to the rules of the 'corrected complex schemes', other allocation limits could also be applied and tested.

4. In the optimisation model, country-specific data and limits and constraints can be specified for each irrigation system (planning zone) and for the energy sector. Maximum levels of investment can be specified, and new irrigation development can be allowed for.

<u>Objectives</u>

5. The objectives of the studies using this model were to:

- Provide a technical basis for further development of interstate water management agreements, particularly those involving the operation of Toktogul and Kairakum reservoirs.

- Provide a strategic overview for investment in water resource infrastructure and irrigated agriculture.
- Determine optimal cropping patterns for several planning zones representative of conditions in various parts of the Basin.

Regional Development Scenarios

6. The studies have considered a number of scenarios for future regional water and salt management plans, allowing for various needs and constraints.

7. Scenario I assumes a situation in which the irrigation systems would deteriorate further due to lack of funds for operation and maintenance. Water management would not improve, agricultural policies would not be reformed, etc. This would result in a negative picture of degrading lands, increased rural poverty, waste of water, lower production levels and a drag to the economic growth of the countries, which to varying degrees depend heavily on the agricultural sector. This scenario obviously is not desirable and is not an option of choice, and consequently no water and salt balance simulations or calculations of economic performance have been undertaken. However, the assumptions of the scenario have been used in evaluating the performance of more desirable scenarios.

8. Scenario II assumes that the current level of performance (i.e. crop yields, system efficiency levels, etc.) in the agricultural sector would be maintained into the future, and that gradually the cropping patterns in each planning zone would be altered within constraining limits to achieve the optimum economic return. Constraints adopted were that any crop area should not decrease below 50% of the 1999 area of that crop, nor increase above levels set by population growth. In the case of Turkmenistan the changes in the constraints over time were not related to population growth but were nominated specifically.

9. Scenario III assumes substantial improvements in the performance of irrigated agriculture through investment in rehabilitation and reconstruction of main, inter-farm and on-farm water supply systems, and better on-farm water management leading to higher water productivity.

Studies

10. Especially for the Syr Darya basin, the above scenarios have been tested for various modes of operation of Toktogul Reservoir: (i) an 'irrigation mode' reflecting the design operation mode of the past, (ii) an 'energy mode' which gives higher priority to power generation in the non-vegetation season, and (iii) an ' irrigation and energy mode' which reflect the intentions of the annual agreements for the operating regime of recent years. In the case of Scenario IIIb, several variants of the irrigation and energy mode have been examined in order to demonstrate impacts on the national economies of certain choices, often of a political nature. The cases studied are summarised in Table 1.

11. In all cases optimum land use is determined for each country, within defined water availability limits, operating mode of the reservoirs, available irrigable area, available funds, and logical limits to the cropped areas for certain crops. Through simulation modelling, the water and salt balances have been determined for each scenario.

12. The scenarios allow for future increases in energy consumption, and additional thermal and hydropower stations (such as Kambarata I and II, and Rogun) have been included to cover demands.

Table 1: Optimisation Cases Studied

Scenario		Case	Mode of Operation of Toktogul	Variant	
No.	Description			No.	Description
I	Little investment, further deterioration over time				
II	Maintain current productivity levels over time	a	Irrigation		Optimum productivity
		b	Energy/Irrig.		Optimum productivity
		c	Energy		Optimum productivity
III	Substantial investment, improved productivity over time	a	Irrigation		Optimum productivity
		b	Energy/Irrig.	1	Optimum productivity
				2	Self sufficiency
				3	Ecological
				4	Dry year
		c	Energy		Optimum productivity

13. The 'self-sufficiency' variant assumes a gradually phasing out of the self-sufficiency policy for cereals, especially wheat production. From an economic point of view wheat is an unprofitable crop for which imports can substitute, making larger areas available for profitable crops.

14. The 'ecological' variant studies the impact on water supplies to the various countries, and on farm productivity, of supplying the necessary volumes of water to the Northern and Larger Aral Seas for environmental sustainability. These have been shown to comprise minimum average flow requirements in the lower reaches of the rivers of 18 km3 per year for the Amu Darya and 11.5 km3 for the Syr Darya, totalling 29.5 km3 per year in all.

15. Model tests initially focused on average flow conditions in order to be able to compare the performance of scenarios under normal conditions. Scenartio IIIb has also been tested for dry year conditions, taking into account the multi-year storage facility of Toktogul reservoir. The 'dry year' variant considers the situation with annual river flows at a once in 10 year exceedence level i.e. with an annual total flow that is exceeded in 90% of years, and examines the impacts that the resulting water shortages have on farm productivity.

Results

16. The results of the optimisation studies are presented in the tables below in terms of the various operating modes of Toktogul reservoir.

Table 2. Total Net Benefits ($US million/year) for the Amu Darya basin, and the Syr Darya basin with Toktogul operated in the irrigation mode in 2025

	Kazakhstan	Kyrgyzstan	Tadjikistan	Turkmenistan	Uzbekistan
Scenario IIa	550	220	797	268	689
Scenario IIIa	634	242	828	488	1,201

Table 3. Total Net Benefits ($US million/year) for the Amu Darya basin, and the Syr Darya basin with Toktogul operated in the irrigation-power mode in 2025

	Kazakhstan	Kyrgyzstan	Tadjikistan	Turkmenistan	Uzbekistan
Scenario IIb	575	232	799	268	684
Scenario IIIb1	644	253	830	488	1,196
Scenario IIIb2	520	213	875	464	794
Scenario IIIb3	631	233	840	412	895
Scenario IIIb4	637	216	758	417	1,105

Table 4. Total Net Benefits ($US million/year) for the Amu Darya basin, and the Syr Darya basin with Toktogul operated in the energy mode in 2025

	Kazakhstan	Kyrgyzstan	Tadjikistan	Turkmenistan	Uzbekistan
Scenario IIc	591	239	803	268	640
Scenario IIIc	703	261	833	488	1,101

Discussion

Toktogul Operating Mode

17. It is clear that, purely from the economic point of view:

- The choice of operation mode for Toktogul reservoir has an impact on the economic performance. The model studies confirm that overall the irrigation mode of operation favours the downstream countries, while the opposite holds for the energy mode.
- A compromise, a combined irrigation-power mode of operation of Toktogul as compared to the original irrigation mode of operation (Scenario IIIa compared with Scenario IIIb1), results in an $11 million per year or 4.5% increase in the benefits for Kyrgyzstan, and a $5 million per year or 0.4% decrease for Uzbekistan. The benefit to Kazakhstan would increase by1.5%. The other countries would be unaffected.
- When looked at from the other side, the benefits for Kyrgyzstan under Scenario III in the irrigation mode are $11 million per year or 4.7% less than in the compromise mode and $19 million per year or 7.9% when compared to the energy mode of operation.

- Overall, the differences are minor in the context of the many other problems that beset the region, suggesting that the issue is not critical in the formulation of strategic plans.

Optimal Cropping Patterns/Food Self-sufficiency

18. Comparison of the results for Scenarios IIIb1 and IIIb2 indicate that, in the case of most of the countries, the policy of self-sufficiency leads to substantially lower total benefits compared with what could be achieved in the optimum situation. This is particularly so in the case of Uzbekistan for which annual losses of about $400 million per year are indicated, a reduction of 33% from the optimum. The impact is also significant in Kazakhstan, where annual losses of $124 million or about 20% are indicated. The other countries are shown to be less affected. The cost of importing wheat or other grains should also be taken into account, and this would reduce the benefits in the optimum case, but the reduction is likely to be substantially less that the increased benefits from the substituted crops.

19. Thus, self-sufficiency has a heavy economic penalty. The benefits, which are related mainly to surety of food supplies, must be weighed against the costs arising from using valuable water resources in the irrigation of low value crops.

Ecological Flows

20. Comparison of Scenarios IIIb1 and IIIb3 gives the effects of providing minimum flows to the Aral Sea and wetlands for sustainability, assuming cropping patterns for optimum productivity. The results indicate that there would be relatively little impact in Kazakhstan, Kyrgyzstan and Tadjikistan. There would be a reduction in benefits of $300 million per year in Uzbekistan, or 25%, while Turkmenistan would suffer a loss of benefit of $76 million or 15%.

Regional and Planning Zone Water Balances

21. The Regional Working Group has undertaken an analysis of the water and salt balance conditions that would prevail in the Aral Sea Basin in the future under the situations described in the national plans. The analysis has involved simulation studies using the RIBASIM model to assess the performance of the supply system under the assumed future conditions for various scenarios, using historical river flow records over 40 years.

22. The results show that the expected future water demands (including a sanitary flow of 3.1 km^3) in the Amu Darya basin would increase from 59.9 km^3/year at present to 68.2 km^3/year by about 2025. Shortages in supply would increase from 2.6 km^3/year to 11.4 km3/year. The results indicate that shortages in the vegetation period would be pronounced in several systems: Surkhandarya (35%), Kashkadarya (23%), and Bukhara (34%), and Balkan (30%), while the Akhalsk and Balkan areas would suffer very large deficits. All other irrigation systems would be supplied with sufficient water in vegetation period or would only have minor shortages occasionally. Deficits would not occur in the non-vegetation period.

23. In regard to the Syr Darya the studies indicate that under the future conditions total water demands (including a sanitary demand of 1.6 km^3) would decrease from the current 42.9 km^3/year to 32.8 km^3/year in 2025. Shortages in supply would be minimal.

24. Noteworthy conclusions from the results of the studies are that, with the development and cropping patterns envisaged in the draft national plans:

- Each country would remain within the established water allocation limits, or would deviate only marginally from the limits.
- Adequate flows for sanitary purposes would be maintained throughout both rivers.
- The river flow in the Syr Darya available for wetlands and the Aral Sea would increase from 3 km^3/year to 5 km^3/year, while in the Amu Darya it would decrease from 8.8 km^3/year to 8.2 km^3/year.
- The level of the Larger Aral Sea would fall another 7 m, while the level of the Northern Aral Sea would stabilise or rise slightly.
- Downstream river water salinity levels would decrease minimally, from an average value in the Amu Darya of 0.8 g/l to 0.77 g/l, with a similar trend in the Syr Darya. Peak values would similarly decrease.
- Due to substantial reductions in the volumes of water supplied per hectare, salt accumulation in the sub-soil, and salt export to desert sinks or rivers, would decrease substantially overall.

25. The land and water use determined in the optimisation modelling has been simulated for the various scenarios developed by the Regional Working Group. In all of the cases investigated the supply deficits are minimal. This is because in each case land use was optimised within the boundaries of average water availability and water allocation limits. Hence shortages are indicated for systems that are entirely or mainly supplied from tributary flow, or are located at the ends of the main stems of the major rivers.

26. With one exception, the total water intake in the Amu Darya Basin was found to be around 57 km3 per year, ranging from 55.6 km3 to 60.0 km3 depending on the scenario. The exception is the scenario giving a high priority to the wetlands and the Aral Sea, in which case the total intake was shown to be limited to about 47 km3 per year.

27. The total water intake in the Syr Darya basin is found to be around 40 km3 per year, ranging from 40.9 km3 to 36.5 km3, with the exception of the scenario giving priority to the wetlands and the Aral Sea when the total intake would be limited to 31.6 km3 per year.

28. Overall, the total water intake for irrigation in the Aral Sea Basin is shown to be about 100 km3 per year.

29. A number of other options for water management and irrigation development will be evaluated during Phase VI, as suggested by the various national teams, the World Bank, and the Independent Panel of Experts.

In-field/Local Salt Balances

Models

30. The infield/local salt balance studies used the Salinity Model developed by the Regional Working Group. The model is based on the SALTMOD computer program, which predicts the salinity of soil moisture, groundwater and drainage water, the depth of the watertable, and the volume of drain discharge, in irrigated agricultural lands. Similar studies were carried out in parallel using a model developed by SANIIRI in order to compare the outcomes of both models.

31. Both models determine soil and groundwater salinity levels under various conditions for a representative unit area, which is defined in terms of soil characteristics and drainage conditions. The calculations are carried out for a number of consecutive years to evaluate the changes in soil and groundwater salinity levels that occur over time. Major outputs are drainage flows and drainage water salinity levels.

Study Objectives

32. The objectives of these studies were to:

- Assess the possibility of salt accumulation in the soil over time under various scenarios, and hence the effects of the scenarios on crop productivity.
- Determine salt outputs under those scenarios, for use in determining planning zone salt balances.
- Evaluate leaching requirements.

Salt Accumulation and Salt Output Studies

Influencing Factors

33. Three main factors influence local salt balances: irrigation water quality, recharge by seepage from canals (sometimes in combination with poor drainage), and leaching practices.

34. The salinity hazards posed by irrigation water can be predicted on the basis of the amount and types of salt contained in the supply water. A number of different irrigation water quality appraisal systems have been developed. The system developed by the US Salinity Laboratory, and an enhanced system by FAO (1976), are the most widely used. The hazard may be diagnosed on the basis of the electrical conductivity (EC) of the irrigation water. Generally it can be stated that ECsoil = b.ECirr_water, the value of b varying with the applied leaching fraction.

35. The FAO guidelines for irrigation water quality appraisal (leaching fraction15%) are as follows:

- EC_{irr}_water < 0.75 dS/m: no problem of soil salinisation
- EC_{irr}_water 0.75-3.0 dS/m: moderate problem of soil salinisation
- EC_{irr}_water > 3.0 dS/m: severe problem of soil salinisation

36. The term seepage refers to (ground) water inflow into an area from outside. Typically, seepage water emerging in irrigation areas has travelled over considerable distances and depths through the soil. Areas subjected to seepage inflow are especially liable to salinisation by groundwater. The seepage rate and the salt content of the seepage water vary throughout the year in line with variations at the source.

37. Percolation of rain and irrigation water has both a recharge effect, which causes watertables to rise and hence encourages soil salinisation, and a leaching effect which tends to reduce soil salinity. In the long term (e.g. on an annual basis) there may well be equilibrium between the two, but serious salinisation may still occur for temporary periods. Temporary salinisation is more likely to occur where there are extended time intervals between leaching events. Thus, serious salinisation may occur when fields are irrigated say every three to four weeks (as is the present common practice in Central Asia) but not when irrigated at say intervals of seven to ten days. The common problem of crops suffering from water stress is also caused by too long irrigation intervals.

Input Parameters

38. As part of Task N8, the National Working Groups provided the Project with monthly data on salinities (weighted averages) in the main system and the drainage collector system for each Planning Zone during the period 1991 to 2000. These numbers (reflecting existing local salt balances) have been used directly in the RIBASIM simulations for the present situation in order to establish regional salt-balances.

39. For scenario 2 (without major investments in the irrigation and drainage sector), it is not foreseen that the situation regarding water salinity will change significantly, and the same figures on the salinity of irrigation and drainage water were used as for the present situation.

40. Under scenario 3, water management practices will change towards a more rational water use, with lower water losses and higher efficiencies. Also, investments in the agricultural sector will lead to better farming practices and better hydrological conditions in the fields, and result in higher productivity. The RWG considers that, through better on-farm practices, irrigation-system efficiencies will improve by up to 25%. In waterlogged areas investments will be made both in new sub-surface drainage systems and in the upgrading of collector drainage systems. Those investments will lead to both a lowering of shallow watertables, varying from 0.6 to 0.9 metres, and a reduction in the adverse effects of secondary salinity.

41. Both higher efficiencies and better drainage conditions were the governing input parameters in calculating the future effects for water and salt flows on a farm level.

Studies

42. The calculations were carried out using the SALTMOD and SANIIRI computer programs for water and salt balances. A description of SALTMOD has been published in RR2. The SANIIRI computer program was especially developed for simulation of water and salt flows under Central Asian irrigation and drainage conditions. During the past 10 years special on-farm field-research programs were developed in order to provide the input data and to verify the outcomes of the model calculations.

43. For a number of representative planning zones in both basins (Fergana, Syr Darya, Hunger Steppe, Kashkadarya/Karshi, Lebab, Bukhara, Karakalpakstan and Kyzyl Orda) SANIIRI carried out water and salt balance calculations which were used to establish future (under Scenario 3) salinities in the collector drainage system in those areas.

44. A short description of characteristic problems in some of these areas is given below:

- Fergana valley, where during the last ten years the area of saline lands has increased and drainage water-salt flow is completely disposed to the Syr Darya thus polluting river water with salts;
- South-Hunger Steppe Canal command area, which is characterized by huge reserves of salts in soils, which cause secondary salinization of irrigated lands;
- North-west part (Pakhtaaral zone of Hunger Steppe), where starting from 1991-1995 operation of vertical drainage systems has been stopped resulting in water-logging and salinization of irrigated lands. At the same time a huge volume of collector drainage water (up to 40%) goes to the main system;
- Kyzyl Orda (mainly production of rice) with a very poor degree of drainage; this fact resulted in an intensive salinization of lands during the last decades.

45. A breakdown of the results is presented in Table 5.

Table 5: Drainage Water Salinity Levels in Various Planning Zones

Planning Zone	Salinity in drain NWG 1991-2000	Salinity in drain SANIIRI (present)	Salinity in drain SALTMOD (scenario 3) 2010-2025	Salinity in drain SANIIRI (scenario 1) 2010-2025	Salinity in drain SANIIRI (scenario 3) 2010-2025
	g/l (measured)	g/l (measured)	*g/l (calculated)*	g/l (calculated)	g/l (calculated)
Fergana	*2.4*	2.6	*1.9*	3.3	1.6
Syr Darya	*2.5*	4.8	*2.0*	3.8	2.0
Hunger Steppe	*2.5*	4.8	*2.1*	3.8	2.0
Kashkadarya	*3.6*	3.7	*2.9*	6.3	3.1
Lebab	*2.5*	4.4	*2.0*	2.6	3.0
Bukhara	*3.6*	3.7	*2.9*	6.5	1.8
Karakalpakstan	*3.3*	3.5	*2.6*	4.1	3.0
Kyzyl Orda	*7.0*	2.9	*5.6*	5.7	2.5

46. There is reasonable agreement between the present drainage salinities calculated by the SANIIRI model and actual recorded salinity levels in the period 1991-2000, giving confidence in the accuracy of the model. There is also very good agreement between the SANIIRI and SALTMOD models, except in the case of Kyzyl Orda.

47. Generally speaking, the studies indicate that salinity levels stabilise after about 10 years, and that on-farm and off-farm improvement measures will lead after that time to a reduction in the salt concentration in the drainage system of between 10% and 25%. As there will be also a basin-wide positive effect on the river salinity, it is believed that the total combined effect on the quality of the drainage water will be even greater. It should be noted that the contribution from saline (shallow) groundwater to the water quality in the drains has a retarding effect. For example, during the first years after construction of a sub-surface drainage system, the relatively high amounts of salt in the root zone and shallow groundwater are reflected in the drainage water quality. According to the calculations, it takes about 5-10 years to create salinity conditions that reflect the newly-introduced water and irrigation management practices.

Study Outputs

48. Outputs from the model studies have been used to determine salt exports from the various planning zones, which are then used as input to the RIBASIM model in the determination of planning zone and regional salt balances described in the next section.

Regional and Planning Zone Salt Balances

49. The RIBASIM model has been used to calculate the average annual change in salt storage in all planning zones. The change in salt storage (the salt balance) is expressed in terms of t/ha. When it is negative, more salt is leaving the planning zone than entering, and this may affect areas further downstream. When it is positive then salt is accumulating in the zone, and this can lead to crop yield reductions.

50. The results of the model studies for all planning zones in the Aral Sea Basin are shown in Table 25 and Table 26 in chapter 7.4.3.

Present conditions

51. Annual changes of more than 2 t/ha are considered to be significant. With annual changes of less than that value it is considered that a zone is more or less in equilibrium, within the level of accuracy of the studies. On that basis the results indicate that, under present conditions, there are significant negative salt balances in the following planning zones: Chakir, Andijan, Fergana, Tashkent Chirchik and Djizak i.e. at present there is a net export of salt from these zones. Significant positive salt balances are indicated for the planning zones: Kampyr Ravat, Khodjent, Tashkent Syr Darya, Kyzyl Kum and especially Kyzyl Orda; salt is therefore accumulating in these zones. In the remaining planning zones the salt balances in equilibrium.

52. The results are similar for the Amu Darya Basin. They show that significant negative salt balances exist in the following planning zones: Surkhandarya, Mary, Akhalsk, Balkan, Kashkadarya, Karshi, Lebab, Navoi and Buchara. In these planning zones there is at present a net export of salts. Significant positive salt balances are indicated for the planning zones situated in the delta of the Amu Darya: Khorezm, Karakalpakstan South and North and Dashkovus; salt is therefore accumulating in these zones. In the remaining planning zones the salt balances are in equilibrium.

53. The objective for all planning zones is eventually to create conditions in which salt balances are in equilibrium.

Salt balances under future conditions

54. From the results it is concluded that, under Scenario 3, the proposed measures lead to a higher number of planning zones with salt balances in a state of equilibrium. The results indicate that salt exports will reduce in planning zones where at present high salt loads are being exported, notably Ferghana and Andijan in the Syr Darya basin and most of the planning zones in Turkmenistan. A reduction in salt accumulation is indicated in Kyzyl Orda, which receives by far the greatest imports of salt, and in planning zones in the Amu Darya delta.

55. In the Syr Darya basin, the self-sufficiency case appears to offer the greatest reductions in salt balance, with only 5 planning zones showing balances greater than 2 t/ha. The ecological case also offers considerable reductions. In the Amu Darya basin the self-sufficiency case generally offers higher reductions in the salt balances in the midstream and downstream planning zones.

56. Overall, the results suggest that measures involving more efficient water use and improved agricultural practices can lead to more favourable salt balances in the Aral Sea Basin. In the longer term the downstream irrigation areas, the wetlands, the floodplains and the Aral Sea itself will profit from these policies and strategies to be implemented.

Leaching requirements

57. It is common practice in irrigation design schemes that the salinities in the lower root zone boundary corresponding to 25% yield reduction are still acceptable. The reason for this is that the weighted average salinity in the root zone (weighted according to root distribution) would still be only related to 0 % to 10% yield reduction, while the salinity in the upper root zone (on which crop response mainly depends) would be close to the 0% crop yield reduction value.

58. Leaching requirements have been calculated for different farm types under future conditions (improvement measures have been applied) in the Aral Sea Basin (source: Smedema L.K. and D.W. Rycroft Land Drainage, chapter 11, equation 11.6, 1983). The results are presented in Table 6.

Table 6: Leaching Requirements with Various Farm Types

Farm type[1]	Soil salinity for 25% yield reduction EC_e (dS/m)	Salinity groundwater (dS/m)	Leaching requirements (m^3/ha/year)
1	6	0.5	< 1,000
2/3	6	0.5	< 1,000
4/5	6	0.5	1,000 – 2,000
6/7	9	6.0	1,000 – 2,000
8/9	9	4.0	1,000 – 2,000
10	12	12	3,000
11	9	8	2,000

1. Farm types are defined in Regional Report 2.

59. The results indicate that, when higher irrigation standards and practices (including reduced seepage losses in the supply system) are in place, the average leaching requirement is between 2,000 and 3,000 m^3/ha per vegetation season. When the fields are laser land levelled, the leaching requirements reduce by 500-1,000 m^3/ha.

60. Normally the amount of water needed for leaching is within the gross irrigation application. For example: the seasonal net crop water requirements amount to 7,000 m^3/ha/year and the in-field irrigation application efficiency is 60% (in this case the gross application amounts to almost 12,000 m^3/ha/year). Approximately 5,000 m^3/ha/year is available for leaching. In general a deep percolation loss of more than 25% is quite common under surface irrigation so that there is generally speaking no need to over-irrigate to satisfy the leaching requirement.

61. It needs to be emphasized that it is assumed that improvement measures have been taken in the on-farm and off-farm supply channel system. The impacts of these measures

on the salinity in the drainage water in representative areas in the basin are calculated with the program developed by the SANIRI 'Central Asian Scientific Research Institute for Irrigation, Tashkent'.

Economic Evaluation of Measures to Improve Infrastructure and Irrigated Agriculture

Main and Interfarm Canals

62. The Regional Working Group has carried out economic cost/benefit analyses of the rehabilitation of existing main and inter-farm canals and associated hydraulic structures, combined with an increase in O&M expenditures up to adequate levels for long term sustainability (assumed to be 1990 levels) in some representative zones: South Kazakhstan (Kazakhstan, Syr Darya basin), Djalalabad (Kyrgyzstan, Syr Darya basin), and Bukhara (Uzbekistan, Amu Darya basin). There are significant differences between these zones in the relative lengths of the canal systems, in the proportion of unlined and lined canals, and in the cropping patterns and crop yields.

63. The rehabilitation measures considered include: removal of silt and vegetation in the canals; rehabilitation of concrete linings; rehabilitation of concrete and reinforcement in hydraulic structures; and replacement of hydraulic gates and electromechanical equipment. It has been assumed that after rehabilitation and an increase in O&M expenditures: i) the efficiency and discharge capacity of main/inter-farm canals will not further decrease; and ii) the efficiency and discharge capacity will increase up to the original design level. The main benefits from the rehabilitation measures and the increase in O&M expenditures have been determined in terms of reductions in existing water deficits in the command areas (due to reduced water losses) and consequent decreased yield losses. The benefits have been calculated on the basis of the existing cropping patterns and yields. A breakdown of the results of the cost benefit analysis is presented in Table 7, together with the results of sensitivity testing of higher cost levels.

Table 7: Rehabilitation of existing main and inter-farm canals and increase of O&M costs

Item	Unit	Oblast/planning zone, country		
		South Kazakhstan, Kazakhstan	Bukhara, Uzbekistan	Djalalabad, Kyrgystan
Length of main and inter-farm canals	m/ha	4.1	5.6	6.2
Unlined	%	75	57	62
Lined	%	25	43	38
Average command area of 1 km of main and inter-farm canals	ha	244	180	161
Capital costs over 25 years	$'000/km	62	106	93
Increase of O&M costs(without depreciation)	$'000/km	3.2	1.8	1.6
NPV (discount rate 10%)	$'000/km	60.7	31.6	12.7
IRR (base case)	%	38	21	16
Sensitivity tests:				
10% higher costs than base case	%	33	18	13
20% higher costs than base case	%	28	16	11

* Methods of calculation of the NPV and IRR are given in the Regional Report No2

64. With IRRs in the range from 16% to 38%, the results indicate that rehabilitation works on the main and inter-farm canal systems, together with increased O&M expenditure, would be economically profitable. Even if the capital costs and increases in O&M expenditure were 20% greater than assumed, this option would be economically viable in all areas considered. The results indicate that the rehabilitation of main and inter-farm canals is close to the most profitable of on-farm measures.

On-farm Measures

65. The Regional Working Group carried out an economic evaluation of various options to improve water and land productivity on common farm types in the region. These farm types are representative of more than 85% of the area of irrigated lands in the Basin.

66. Taking into consideration the limited resources of the Aral Sea Basin countries to finance investments in the irrigation and drainage sectors, the RWG focussed mainly on the economically more profitable on-farm options, having an IRR ranging from 18% to 40%. More detailed descriptions are given in the Regional Report 2. An overview is presented below:

- Improving traditional irrigation in all planning zones for all the irrigated areas (average capital costs = $US146/ha, average increment of O&M costs = $US23/ha). This option includes low cost measures at farm level on improvement of water management, decrease of operational water losses, and increase of crop yield.
- Laser land levelling in all planning zones, in 40-50% of the irrigation areas (when determining the total area for laser land leveling the following was accounted for: i) the irrigation areas mentioned by NWG for complex

reconstruction, for top-priority modernization of water application technology; ii) analysis by RWG (average capital costs = $US512/ha, average increment of O&M costs = $US16/ha).

- Improving field drainage by rehabilitation or installing sub-surface drainage in all planning zones, mainly in the irrigation areas suffering from waterlogging and moderately saline and severely saline soils. The plans from NWGs for reconstruction of the existing on-farm drainage and new installation of on-farm drainage were taken into consideration. Average capital costs = $US1260/ha, average increment of O&M costs = $US40/ha. The option includes complete rehabilitation/new construction of on-farm drainage, including collectors, plus capital soil leaching.

67. The conclusions of this study are that:

- Rehabilitation of worn out, broken and non-operational irrigation and drainage infrastructure will:
  - ensure stable operation of the infrastructure;
  - prevent future decreases in crop yields on irrigated lands and in the efficiencies of irrigation systems.
- A combination of 'improving traditional irrigation' and 'rehabilitation of irrigation infrastructure' will increase crop yields on average about 1.5 times and will increase the efficiency of irrigation systems by 3-6%.
- Combining 'improving traditional irrigation' and 'rehabilitation of irrigation infrastructure' and 'laser land levelling' will increase crop yield on average about 1.7 times, and will increase the efficiency of the whole irrigation system (including field irrigations) by 6-9%.
- A combination of 'improving traditional irrigation' and 'rehabilitation of irrigation infrastructure, inter-farm and main collectors' and 'laser land leveling' and 'improving field drainage' will increase crop yield in average 2.5 times (predominantly on moderately saline and severely saline irrigated lands).
- Rehabilitation of main and inter-farm canals and associated hydraulic structures (together with additional O&M expenditure) is economically profitable, offering IRRs in the range 16- 38%.

Economic Evaluation of New Lands Development

68. According to data provided by the NWGs, the costs of constructing irrigation and drainage infrastructure in new land developments varies between $1,400/ha where the channels are largely unlined (e.g. Kyrgyzstan) up to $4,500/ha where channels are fully lined (e.g. Uzbekistan). To these costs must be added the costs of agricultural development (initial processing of land, construction of roads, repair shops, storehouses, etc.), which are approximately $1,000-2,000/ha, and social infrastructure such as housing, hospitals, schools, etc. at approximately $1,000-1,500/ha. O&M costs (excluding depreciation) are estimated at about $100/ha for adequate maintenance of the irrigation and drainage

systems. The capital costs are lower where new lands are developed on the basis of existing main irrigation and drainage infrastructure.

69. Economic analyses were undertaken by the RWG for various representative conditions and main crops, assuming conditions of low, medium and high fertility, corresponding with 40, 60 and 80 points on a 100-point scale (bonitet-growth class). The studies assumed a construction period of 3 years, with agricultural production starting in the fourth year. A project period of 30 years was assumed, and an economic discount rate of 10%.

70. The results showed that:

- Where the costs of new lands development include all costs of main irrigation and drainage infrastructure, agricultural development and social infrastructure, such developments are uneconomic under all conditions, even with highly fertile soils and high value crops.
- Even where main irrigation and drainage infrastructure exists, new lands development is uneconomic unless the necessary water supplies can be obtained without expenditure on water saving measures in existing irrigated areas. This is rarely possible with the limited supplies available in the Aral Sea basin.
- Where water for new lands development can be obtained without expenditure on water saving measures in existing irrigated areas, but construction costs are high due to the need to line most canals, development of new lands would be economic only with cotton grown on high fertility soils or with vegetables on high or medium fertility soils. Where the development does not involve lined canals or canalettes, cotton and vegetables on high or average fertility lands would be economic. Cotton-wheat specialisation on new lands would not be economic under any conditions.

71. Consequently, the opportunities for the economic development of new lands are very limited because:

- There are minimal land reserves of high or medium fertility available, as the most of such areas have already been developed.
- Large-scale vegetable-growing is not a viable option, as vegetable requirements are limited by local markets.
- There is no water available currently for such developments, and irrigation would have to rely on savings of water from old irrigated lands.

72. However, new lands development may have significant social effects in rural areas as the population increases. For example, 1,000 ha of new land under cotton will provide employment for about 400 people, providing annual incomes to the farmers of about $150/ha and supporting up to 1,500 people.

APPENDIX 4

INTERSTATE FRAMEWORK AGREEMENT
ON THE RATIONAL USE OF WATER AND ENERGY RESOURCES
OF THE NARYN-SYR DARYA CASCADE

1998

PROTOCOL
ABOUT INTRODUCTION OF CHANGES AND AMENDMENTS TO THE AGREEMENT BETWEEN THE GOVERNMENTS OF THE REPUBLIC OF KAZAKHSTAN, THE KYRGYZ REPUBLIC, AND THE REPUBLIC OF UZBEKISTAN ON THE USE OF WATER AND ENERGY RESOURCES OF THE SYR DARYA BASIN FROM 17 MARCH 1998

17 JUNE 1999

Agreement
Between the Governments of the Republic of Kazakhstan, the Kyrgyz Republic, and the Republic of Uzbekistan on the Use of Water and Energy Resources of the Syr Darya Basin

The Governments of the Republic of Kazakhstan, the Kyrgyz Republic, and the Republic of Uzbekistan, hereinafter referred to as the Parties:
GUIDED by sincere spirits of good-neighborliness and cooperation;
RECOGNIZING the fact that the appointed countries followed the agreed procedure of Syr Darya Basin Water and Energy Uses, ensuring social and economic development of their countries and people's welfare;
NOTING that the Syr Darya basin, comprised of the area of four countries, has water and energy resources to promote the economic growth of the countries;
HAVING a common desire to find the most precise and fair solution to use the water and energy resources of the Syr Darya basin in accordance with the precedents of international law;
ACKNOWLEDGING that benefits derived from the joint operation of the reservoirs of the Naryn-Syr Darya Cascade, through a multi-year flow regulation and the flood control measures, include the use of water for irrigation and power generation;
TAKING INTO ACCOUNT that a joint and comprehensive use of the water and energy resources of the Syr Darya basin must be implemented with regards to the environmental safety of the region;
NOTING the common interests of the participating countries and the urgent need for the development of an efficient and coordinated water regime in the Syr Darya basin, taking into account the problems of the Aral Sea; the Parties agree on the following:

ARTICLE I
Definitions
"Naryn Syr Darya Cascade" refers to the aggregate of the multi-year and seasonal regulation reservoirs. "Growing period" is defined as the period from April 1 to October 1. "Non-growing season" is defined as the period from October 1 to April 1. "Water management year" is defined as the period from October 1 to October 1 of the following year.

ARTICLE II
To ensure the agreed-upon operating regimes of the hydrotechnical facilities and the reservoirs of the Naryn-Syr Darya Cascade and irrigation water releases, the Parties deem it necessary annually to coordinate and make decisions on water releases, production and transit of electricity, and compensations for energy losses, on an equivalent basis.

ARTICLE III
The Parties will take no actions which will violate the agreed-upon water use regimes and energy deliveries, or infringe on the rights of the other Parties to obtain water and energy deliveries in the mutually-agreed amounts or to transport resources through their own territories.

ARTICLE IV
The Naryn-Syr Darya excess power emanating from the release mode utilized on the Naryn-Syr Darya during the growing season, and the Toktogul multi-year regulated flows that exceed the needs of the Kyrgyz Republic, will be transferred to the republics of Kazakhstan and Uzbekistan in equal portions.

Compensation shall be made in equivalent amounts of energy resources, such as coal, gas, electricity and fuel oil, and the rendering of other types of products (labor, services), or in

monetary terms as agreed upon, for annual and multi-year water irrigation storage in the reservoirs.
A single tariff policy for all types of energy resources and their transportation shall be applied for mutual settlements.

ARTICLE V

The Parties shall undertake essential measures which will ensure the fulfillment of their Agreement commitments to the other Parties using various forms of guarantees, such as lines of credit, security deposits, or other forms.

ARTICLE VI

The Parties agree that customs fees and duties will not be applied for deliveries of energy or other types of products (labor and services) within the Agreement.

ARTICLE VII

The Parties agree that the operation, maintenance and reconstruction of water and energy facilities shall be covered in accordance with the ownership of the property referred to in the balance sheet and the legal right of ownership.

ARTICLE VIII

Reservoir operation modes, energy amounts and transfers are approved by annual intergovernmental agreements based on the decisions made by water, fuel and energy organizations headed by vice prime ministers of the signatory countries.
The BVO Syr Darya and UDC Energia shall be appointed as executive bodies responsible for the release schedules and energy transfers prior to the establishment of the International Water and Energy Consortium and its executive body.

ARTICLE IX

Any disputes or disagreements will be resolved through negotiations and consultations. If the Parties do not reach an accord the issue in dispute shall be considered by an arbitration court that will be established by the Parties for each specific case.

ARTICLE X

To provide further improvement of the management and use of the water and energy resources and the enhancement of economic relations aimed at guaranteed water supply in the basin, the Parties agree to consider jointly the following issues:
- Construction of new hydropower facilities and reservoirs, or alternative sources for hydropower in the region;
- Replacement of barter settlements by financial relations;
- Development of pricing mechanisms based on a single tariff policy;
- Ensuring safe operation of hydrotechnical facilities in the Syr Darya Basin;
- Economic and rational water use with the application of water-conservation technologies and irrigation equipment; and
- Reduction and discontinuation of polluted water discharges in the water sources of the Syr Darya basin.

ARTICLE XI

This Agreement shall be in force from the date the Parties forward the notification of depository on the implementation of the internal state procedures to enforce it.

ARTICLE XII

This Agreement is valid for a period of five years and will be automatically renewed for additional five-year periods, if no written notice on the termination of the Agreement is given six months in advance from any Party.

ARTICLE XIII

This Agreement is open for other countries to enter.

ARTICLE XIV

Given the mutual consent of the Parties, amendments and addenda can be introduced and formalized by separate protocols, and will become integral parts of the Agreement. This Agreement is finalized in Bishkek, March 17, 1998, in one original copy in Russian. The original copy remains in the office of the ICKKU Executive Committee, which will submit certified copies to each member country having signed the Agreement.

Signatories:

For the Government of the Republic of Kazakhstan	**For the Government of the Kyrgyz Republic**	**For the Government of the Republic of Uzbekistan**
N. BALGIMBAEV	**A. DJUMAGULOV**	**U. SULTANOV**

Council of Prime-Ministers
Protocol
about Introduction of Changes and Amendments to the Agreement
Between the Governments of the Republic of Kazakhstan,
the Kyrgyz Republic, and the Republic of Uzbekistan
on the Use of Water and Energy Resources of the Syr Darya Basin
from 17 March 1998

Within the objectives of most effective cooperation of the Republic of Tadjikistan with the countries-participants of the Agreement on the establishment of common economic space in water-energy issues and upon the declaration of the government of Tadjikistan from 19 June 1998 the Council of Prime-Ministers of the countries – CAEC agreed on introducing the following changes and amendments into the Agreement between the Governments of the Republic of Kazakhstan, Kyrgyz Republic and the Republic of Uzbekistan on the Use of Water-Energy Resources of the Syr Darya Basin from 17 March 1998:

add the words "…**Republic of Tadjikistan**…" to the title of mentioned Agreement and first paragraph of the Preamble after the words "…Kyrgyz Republic,…";

add the following paragraph to the Article 4:

"**Republic of Tadjikistan ensure the agreed by the parties operational mode of Kairakkum water reservoir on annual basis. Republic of Kazakhstan and Republic of Uzbekistan provide energy supply to the Republic of Tadjikistan in equal shares in the period of water accumulation with subsequent return of agreed equivalent amount of energy in summer period…**";

Article 11 put in the following wording:

"**Agreement comes into force from the date of signing it by the Parties**."

This Agreement is performed in Bishkek, June 17, 1999, in one original copy in Russian. The original copy remains in the office of the CAEC Executive Committee, which shall submit certified copies to each member country having signed the Agreement.

For the Government of the Republic of Kazakhstan	**For the Government of the Kyrgyz Republic**	**For the Government of the Republic of Tadjikistan**	**For the Government of the Republic of Uzbekistan**
N. BALGIMBAEV	**A MURALIEV**	**YA. AZIMOV**	**U. SULTANOV**

APPENDIX 5

LONG-TERM PERSPECTIVE FOR INSTITUTIONAL STRENGTHENING

International Approaches to River Basin Institutional Strengthening

1. International experience in many river basins, such as in Australia and the countries of the Lower Mekong River Basin (Thailand, Laos, Cambodia and Vietnam), has confirmed that sustainable water resources management and development can best be achieved at the regional (basin) level.

2. Ideally, the most senior representatives from the States ought to be assembled at the Aral Sea Basin level with clearly defined responsibilities, and supported by legislation and regulations. This could ensure that decisions on broad, sustainable water resources and energy management and development, agricultural reform, and ecological improvement are made in the best interests of the basin as a whole, and ensure the essential coordination, implementation and enforcement of those decisions in the States.

3. The numerous river basin agencies throughout the world have been established fundamentally in accordance with one of three models – a River Basin Authority, a River Basin Coordinating Committee or Council, or a River Basin Commission. The respective features of the three models follow.

River Basin Authority

- This type of agency performs all of the water and water-related resource management functions within a river basin.
- It is a large multi-disciplinary agency or organisation responsible for both regulation and operation and management functions.
- It is used where there is a large, long-term development project to be undertaken, often with many facets or components.
- Usually the existing agencies or departments within the States or provinces in the basin would be weak or ineffective to justify using this model (an example was the establishment of the Tennessee Valley Authority in the USA some 60 years ago).
- This is the ‘strongest’ or most powerful intervention in basin management.

River Basin Coordinating Committee or Council

- This model normally comprises the heads of all relevant ministries, agencies, or departments, with a small supporting secretariat.
- It essentially coordinates high-level policy and strategy matters and have no role in daily operation or management.
- This arrangement is often used in ‘developed’ countries where most development is completed, where water trading and other economic instruments are in place, and the water sector is in a stable or mature situation.
- This is the ‘softest’ or ‘weakest’ intervention in the overall management of a river basin.

River Basin Commission

- This model sits between the River Basin Authority and the River Basin Coordinating Council in terms of influence within a river basin.
- It deals mostly with policy and strategy formulation, developing standards and quality control procedures, endorsing operating criteria, undertaking long-term planning, and ensuring data and information are suitable basin-wide.
- Some operating functions may exist for very major works or for inter-State boundary issues, but most operation and management issues remain with the individual countries within the basin.
- A feature of this model is that it is a 'partnership' between the commission and the countries within the basin.
- This model, or variations of it, are being used more frequently in the present era when all key stakeholders in a basin need to be involved in major policy decisions.

4. Each of these models is contingent on the availability of good data monitoring networks (surface and groundwater, water quantity and quality, as well as other natural resources data) which are represented basin-wide, and collection, processing and storage systems are adequate, and the information is available to all stakeholders. Hydrologic and socio-economic models must also be available to support and test the impact of any new policies or management and development proposals.

Potential Future Arrangements

River Basin Commission

5. For the longer term it is suggested that the existing institutions would gradually move towards the model of the River Basin Commission as the most appropriate institutional model for the Aral Sea Basin. At present there is no single regional authority in the basin at a high enough level to ensure complete, unequivocal jurisdiction over the water, energy, and environment sectors, or one that can balance the diverse objectives and problems. The absence of such a regional organisation enables the project interests of one sector or one or two countries to dominate the decision-making process in a way that may not necessarily be in the best interests of the basin as a whole.

6. Establishment of a River Basin Commission, by effectively broadening, strengthening, and re-focusing ICWC and IFAS, would build on the cooperation, collaboration and experience developed since 1992. It would be a logical continuation and expansion of the existing arrangements, be consistent with the central Asian social systems that rely heavily on personal relationships, and would allow for negotiation and bargaining.

7. Establishment of a River Basin Commission would:

- expedite work towards achieving sustainable resource management and development;
- avoid project duplication and confusion;
- ensure efficient and effective resource allocation annually;

- create a strong, internationally-recognised organisation; and
- maximise the potential financial assistance available from the international donor community.

8. The move towards a River Basin Commission, as an institutional framework model to be attained in the long term (possibly over a decade), would be a logical evolution of the existing IFAS arrangements. It would be achieved by effectively adding the energy sector to broaden and strengthen the mandate, responsibilities and capabilities of the existing arrangements involving IFAS, ICWC, CSD and the Energy Council.

Composition of a Commission

9. It is suggested that a Commission could consist of four components as shown in Figure 3:

- a **Council** of the Prime Ministers or Vice Prime Ministers with the responsibility for policy and decisions, supported by
- a **Joint Committee,** consisting of the three ministers from each of the States responsible for water, energy and the environment, charged with the responsibility for making recommendations to Council and implementing the Council's decisions; through
- a permanent **Secretariat,** with staff appropriately qualified in water resources, agriculture, energy, environment, law, hydrometeorology, etc. drawn from the various regional and State agencies, together with donor experts from the international community, which would be responsible for administration and technical advice; and
- the **BVOs**, with appropriately qualified staff, which would be responsible for the operation, maintenance and monitoring of the water supply and distribution infrastructure under the jurisdiction of the Commission.

OPTION FOR A LONG TERM ARAL SEA BASIN INSTITUTIONAL ARRANGEMENT

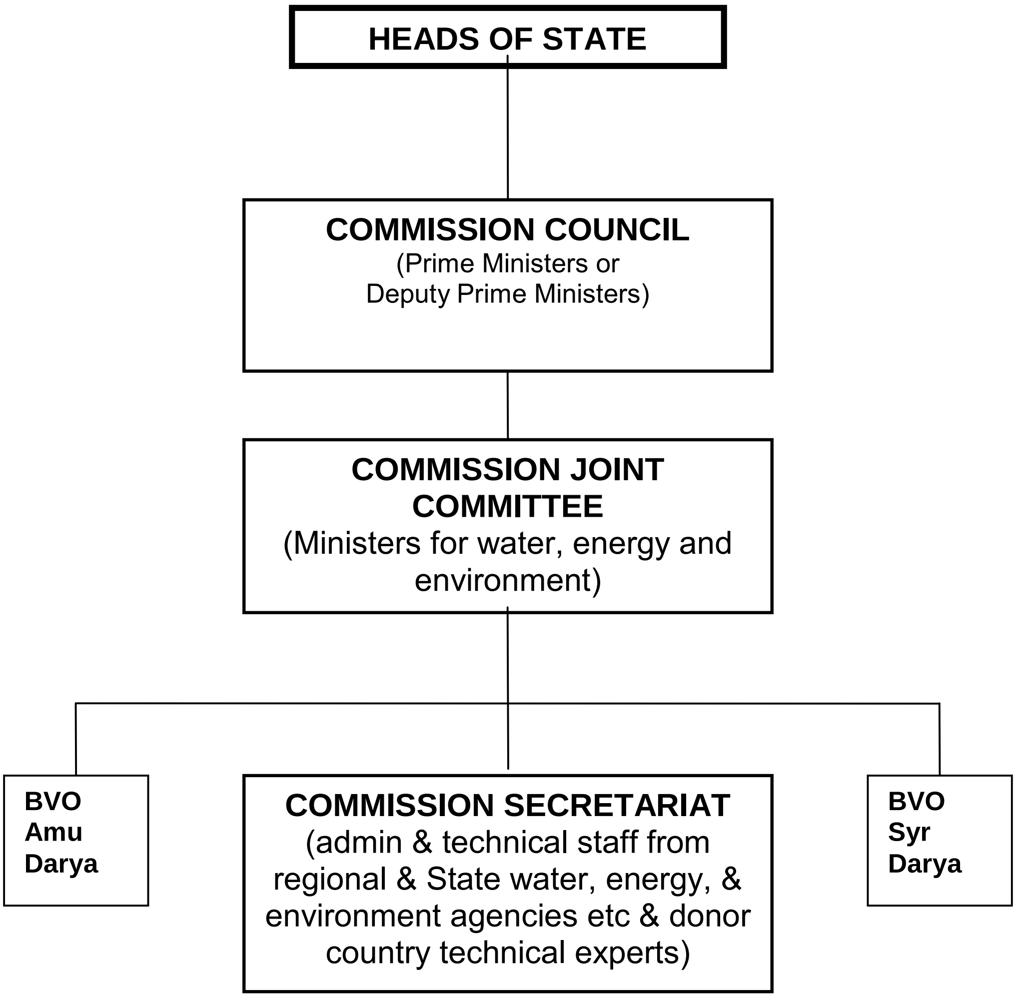

Figure 3

10. In addition to broadening and strengthening the mandate of IFAS, and making it more representative of the key stakeholders, this arrangement would provide a much simpler decision-making and administrative structure by reducing the number of primary bodies from ten to five. By combining the functions of the ICWC and CSD secretariats and SICs into one body, a much more integrated approach to basin management would be achieved.

Responsibilities of a Commission

11. The responsibilities of a Commission could include:

- Determining broad water resources allocations (surface and groundwater) for the States in accordance with the UN/ECE ‘Convention on the Protection and Use of Transboundary Watercourses and International Lakes’, Helsinki, 1992. Amongst other things, this Convention confirm that each basin State is entitled, within its territory, to a reasonable and equitable share in the beneficial uses of the waters of the basin.
- Further development of broad policies and programs promoting sustainable water resources management, particularly with respect to:
  - river salinity standards, control mechanisms andmanagement;
  - promotion of increased water use (especially irrigation) efficiency through demand management mechanisms and community/farmer education;
  - environmental demands.
- Preparation and supervision of comprehensive, regional (basin-wide) water and salt management strategies/plans that would provide the basis for guiding agricultural reform and the development and management of major multipurpose projects, and would outline mainstream water quality and environmental conditions etc. It is suggested that these plans would be essential to the preparation of national plans, but would not dictate the ways in which the States should utilise their water allocations.
- Operation, maintenance and monitoring of water supply and distribution infrastructure on the transboundary rivers.

12. It is suggested that a primary responsibility of the Commission would be to ensure that the agreed national water allocations and return flows, and arrangements for intra-regional energy trade and distribution, are honoured in practice; that they are delivered in a manner that meets the requirements of the States and are in the best interests of the Aral Sea Basin as a whole; and that other intra-regional commitments are met. More specifically, the Commission’s functions would include policy and planning, standard setting and auditing, coordination and dispute resolution, data collection and compilation, monitoring the national allocations, and public awareness and education.

Management Arrangements for a Commission

13. Irrespective of the degree of support for a Commission, it would probably not be possible in the short-term because of political and economic constraints. For example, some governments do not permit several ministers to leave their posts on the same day, so

that the Joint Committee with the suggested composition could not convene. However, it is suggested that a decision to establish a Commission 'in principle' would send a strong signal to the international donor community (World Bank, Asian Development Bank, European Union, USAID, etc.) and assist greatly in the provision of technical and financial support.

14. The Nile Basin Initiative provides a recent clear indicator of available support where nations genuinely want to cooperate. In that case, and despite serious potential conflicts between the ten riparian countries, a multi-track diplomacy approach among the key nations has now resulted in an encouraging level of cooperation. According to the World Bank Development News of 31 July 2001: "the 10 Nile countries have decided to rise above national differences and pursue a common social and economic vision by establishing the Nile Basin Initiative. In June 2001 the international donor community pledged $140 million in grants to implement a basin-wide program of research, capacity building and technical assistance, and begin detailed planning of investment programs, the first of which is expected to amount to $3 billion."

15. Although establishment of a Commission may be an initiative for the future, it is suggested that the Council Chairman should sit for a two-year term and that the position should rotate according to the alphabetical listing of the member States. The Council would convene at least two regular sessions every year, and might convene special sessions whenever considered necessary or upon the request of a member State. The Council would also decide the location of the permanent office of the Secretariat and, if necessary, a headquarters agreement would be negotiated and entered into with the host government.

16. It is suggested that the Chairman of the Joint Committee should also sit for a two-year term, and that the position should rotate according to the reverse alphabetical listing of the member States. The Joint Committee would desirably convene at least three regular sessions every year, and convene special sessions whenever considered necessary or upon the request of a member State.

17. The **Secretariat** would be responsible for providing technical advice and administrative support services to the Council and the Joint Committee, and be under the supervision of the Joint Committee. More specifically, it would assist the Joint Committee in implementation, evaluation and management of programs, projects and activities; maintain databases; formulate an annual work program; prepare other plans and program documents; and undertake such studies and assessments as might be required.

18. The Secretariat would operate under the direction of a Chief Executive Officer (CEO) appointed by Council. It is suggested that consideration be given to recruiting the initial CEO on a five-year term from outside the States following world-wide advertisement of the position. The position of Deputy CEO could rotate among the States on a two-year term consistent with that of the Joint Committee Chairman, and the five key division directors could be appointed from each of the States.

19. Although it is expected that a significant number of the Secretariat staff would be drawn from the SIC-ICWC and SIC-CSD, it is suggested that other staff from riparian countries with specific expertise in water resources, agriculture, energy, environment, law, hydrometeorology etc. be recruited on the basis of technical competence, and the number of posts assigned on an equitable basis among the member republics. It is suggested that

staff be recruited for no more than two three-year terms, except as otherwise decided by the Joint Committee.

20. The **BVOs** would continue to operate, but possibly with a wider mandate. Whilst they have, at least nominally, the responsibility for operating the transboundary rivers, they do not operate any of the key reservoirs nor do they have any power to enforce reservoir operations. In the Syr Darya Basin for example, operation of the Naryn-Syr Darya Cascade (Toktogul, Kurpsay, Tashkumir, Shamalaysay and Uchkurgam), Andijan, Kayrakum, Farkhad, Charvak and Chardara is undertaken by various agencies from Kyrgyzstan, Uzbekistan, Tajikistan and Kazakhstan, and the BVO effectively operates as a monitoring organisation.

21. In the case of the Amu Darya, the situation is currently less constrained, with Turkmenistan and Uzbekistan having a water-sharing agreement in place. However, the future development of Tadjikistan's vast water resources, and those generated in Afghanistan, both of which are largely unregulated, could affect other countries, which suggests that it may be advantageous to develop a basin agreement to ensure sustainable development.

22. For the future, the operational management options for the BVOs could include:

- maintaining their existing monitoring roles (which would not assist in working towards the goal for sustainable water resources management);
- leaving the day-to-day operation and maintenance responsibility for the reservoirs as outlined previously to the various State agencies, although subject to the direction of the BVOs with respect to diversions in each river reach (e.g. in the Syr Darya system the river reaches could be: Toktogul to the Karadarya confluence, Andijan to Naryn confluence, Karadarya/Naryn confluence to Kayrakum, Kayrakum to Farkhad, Farkhad to Chirchik confluence, Charvak to Syr Darya confluence, Syr Darya/Chirchik confluence to Chardara, and Chardara to the delta). This option would require that the BVOs be given appropriate funding by the States and the legal authority to enforce penalties for non-compliance.

23. The option of transferring to the BVOs ownership of the major water reservoirs and hydro-generation facilities, together with the mandate to operate them only in accordance with ICWC policy, is not considered a realistic option at this stage.

24. To operate effectively the BVOs need security of funding. They also need the assurance that, not only will they receive all their budgeted funds, but they have the management flexibility to carry out any repairs and maintenance that are urgently required.

National Aral Sea Basin Committees

25. For the long-term it is further suggested that national committees be established in each of the States to assist the Commission Secretariat in providing advice to the Joint Committee to ensure essential communication, coordination and implementation of the Commission's policies, programs and activities. Each national committee would be chaired by a Joint Committee member and would be representative of all water, energy and environment interests, including the Ministry of Finance, and serviced by a permanent office.