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

REGIONAL REPORT NO. 3

DRAFT REGIONAL POLICY, STRATEGY, AND ACTION PROGRAM FOR WATER AND SALT MANAGEMENT

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ROYAL HASKONING

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GLOSSARY

ASBP	Aral Sea Basin Program
ASBOM	Aral Sea Basin Optimisation Model
BCR	Benefit Cost Ratio – an economic criterion
BSL	Baltic Sea Level – level datum commonly used in USSR
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
IRR	Internal Rate of Return - an economic criterion
LAS	Larger Aral Sea
NAS	Northern part of the Aral Sea
NPV	Net Present Value - an economic criterion
NSDC	Naryn-Syr Darya Cascade
NWG	National Working Group.
O&M	Operating and Maintenance
PMCU	Project Management and Coordination Unit
RIBASIM	RIver BAsin SImulation Model (software package)
RWG	Regional Working Group.
SALTMOD	A computer program for the prediction of soil salinity
SANIIRI	Central Asian Scientific Research Institute for Rationalisation and Irrigation
SAR	Sodium Adsorption Ratio
SIC-ICWC	Scientific Information Centre of ICWC
TDS	Total Dissolved Solids
USAID	US Agency for International Development
US EPA	US Environmental Protection Agency
WAS	Western Part of the Aral Sea
WEMP	Water and Environmental Management Project

PREAMBLE

Introduction

1. The preparation of the Water and Environmental Management Project has been started for the purpose of implementation a "Program of Concrete actions for the improvement of the environmental situation in the Aral sea basin" approved by the Heads of CA states in January 11, 1994 (Nukus). The Project has been approved by the Heads of CA states in April 9, 1999 in Ashgabat and was supported by Ashgabat Declaration (April 9, 1999) and Dushanbe 2002.

Project's Objectives (Subcomponent A1 "National and Regional Water and Salt Management")

2. Project's Objectives are to develop national plans and regional strategy for rational use of water recourses and salt control in region taking into account economical, ecological and social tasks of the region's states within the limited water recourses. During the Project implementation a mechanism for joining interests of each state has been developed with short, middle and long-term perspective in regional water and environmental management.

Scope of the Project

3. According to the ToR approved, the Project consists of VI main Phases and 11 concrete tasks. All studies carried out are included into relevant reports, which during implementation were agreed in established order in accordance with the Contract and recommendations of PMCU.

Summary

4. The present Summary is an integrated document developed on the basis of the reports of Phases I-VI under the Subcomponent A1, measures for completion of Phase VI implementation, comments and recommendations of ICWC members and other ministries and agencies of the region's states concerned.

5. The summary presents the results of joint studies of International Consultant, RWG, NWGs, ICWC WG and other regional organizations during 3 years, indicates main problem issues in the Aral sea basin for joint water and energy management, shows possible options for its improvement and development scenarios for short, middle and long-term perspective. It gives proposals on strategic plan for further collaboration in joint rational use and management of water and energy recourses in the Aral sea basin, which would be defined more precisely for decision makers during implementation of the next Phase VII according to the ToR of Subcomponent A1.

Prospective of Project Development

6. Phase VII is not a task of the International Consultant. However, it is important stage for consensus achievement between the States in some problem issues, projects, strategies and action programs, developed during Phases I-VI implementation.

7. During Phase VII implementation it is necessary to hold a number of meetings with decision-makers. During these meetings, and on the basis of the final product of

Phase VI, decision-makers will have to develop a strategic guideline on following main issues:

a) balance providing between, on the one hand river waters protection (mineralization, ecological flows for deltas and the Aral sea shore and the Aral sea itself and, on the other hand, irrigation and drainage issues;

b) development and coordination national and regional rational water use programmes;

c) flow regulation by joint reservoir operation

d) further consideration and improvement water sharing principles between the states;

e) improvement existing basin infrastructure and new infrastructure development;

f) coordination and adoption new Strategic Action Program in the framework of measures carried out by IFAS.

1. INTRODUCTION

1.1 Project Aims and Structure

8. 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;
- improvement of the operation and maintenance of main and on-farm irrigation and drainage systems.

9. A further aim is to develop a framework that will enable interstate cooperation in water and salt management, and will allow for the preparation of interstate agreements relating to:

- water allocation mechanisms and river salinity standards,
- investment in national and regional water infrastructure, and
- the establishment and funding of the Basin agencies in charge of water resources and infrastructure.

10. The team for Sub-component A1 comprises the Regional Working Group (RWG), which is a core group with a Basin-wide perspective, together with National Working Groups (NWGs) from the five Central Asian republics. The latter groups address the issues of salt and water management from the viewpoints of the individual nations.

11. There are several phases to Subcomponent A1. Phases I, II, III, IV, and V have been completed, and the results and outcomes are described respectively in Joint Report No.1 (Inception Report), Regional Report No.1 (Principles and Guidelines for Regional and National Planning), Regional Report No.2 (Regional Needs and Constraints), National Reports No.1 (National Water Demands and Options for Demand Management), and Joint Report No.2 (Basin Water and Salt Balances and Their Implications for National and Regional Planning). This current report describes Phase VI, which comprises Task R9 of the Terms of Reference that has been undertaken by the Regional Working Group.

12. Concurrently with Task R9, Task N9, involving the preparation of national water and salt management plans, has been undertaken by all of the five NWGs, and the results are described in a series of National Reports No.2, one from each nation.

1.2 Phase VI Task

13. The original Terms of Reference for the project call for the execution of Task R9 – Draft Regional Policy, Strategy, and Action Program for Water and Salt Management.

14. The RWG is required by the Terms of Reference to prepare the first draft regional policy, strategy, and action program for water and salt management in

consultation with the NWGs. The overall objective of this task R9 is the integration of regional and national perspectives, and addressing the major issues in order to enable political decision makers to carry the harmonization and integration process between national and regional planning in its final phase.

15. The regional policy, strategy, and action program is consistent with the strategic choices presented in Joint Report No.2. It is structured and presented in a similar way as National Report No.2 in accordance with Section 4.8 of the Terms of Reference.

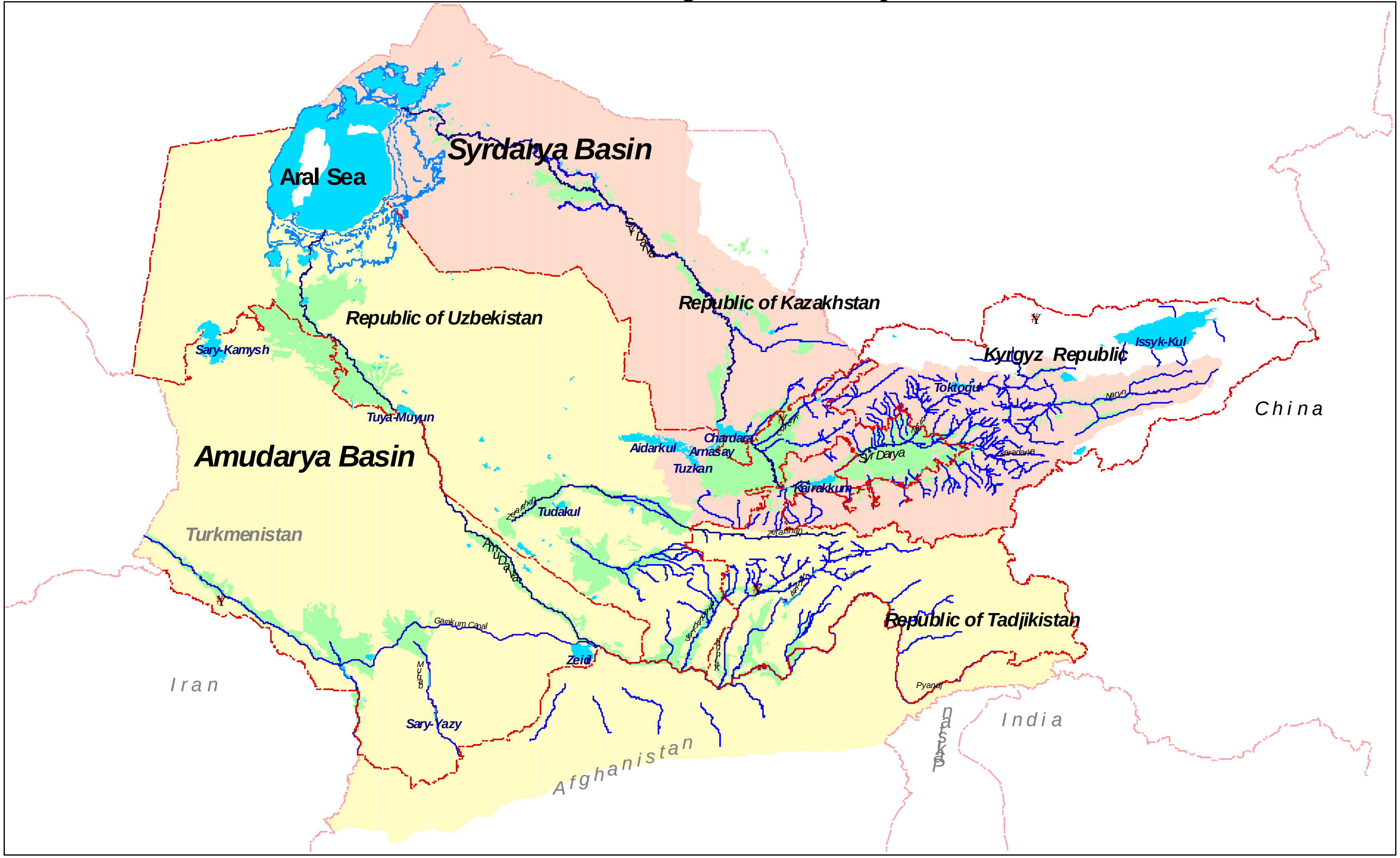
1.3 Purpose and Format of Report

16. The purpose of this report is to present the draft regional policy, strategy, and action program for water and salt management. It is based on the results of the previous phases and on the findings and proposals presented in Joint Report No.2.

17. Regional Report No.3 is presented on two levels to suit different categories of readers. It comprises:

- Executive Summary, and
- Main Report.

Figure 1 Basin map



2. FUTURE WATER AVAILABILITY

2.1 Current Situation

2.1.1 Surface Water Resources

18. The Aral Sea basin comprises the Amu Darya and Syr Darya river basins, and is shared by five Republics of the former Soviet Union: Kazakhstan, the Kyrgyz Republic, Turkmenistan, Tajikistan and Uzbekistan. These states cover 87% of the area of the Aral Sea basin; the remaining 13% is situated on the territories of Afghanistan and Iran.

19. The surface water resources of the Aral Sea basin, based on long-term records, are summarised in Table 1. They indicate a total long-term annual flow of 116 km^3.

Table 1: Water Resources of the Aral Sea Basin

River Basin	Long Term Average Annual Flow (km^3/year)
Amu Darya Basin	
Pyandj	36.0
Vaksh	20.8
Kafirnigan	5.9
Surkhandarya and Sherabad	4.0
Kashkadarya	1.6
Zerafshan	5.3
Total	**73.6**
Syr Darya Basin	
Naryn	13.8
Ferghana Valley rivers	12.8
Akhangaran basin	1.2
Chirchik basin	7.8
Arys basin	2.0
Others	1.2
Total	**38.8**
Turkmenistan rivers (Tedjen, Murgab, Atrek, etc.)	3.2
Total for Aral Sea Basin	**115.6**

Source: RWG report on Subtask R7/1 ‘Review existing water and salt balance studies’, March 2001. Table 3.1.

20. The pattern of maximum flows in late spring and summer and the minimum in winter still generally applies in the upper river reaches. However, it has been modified substantially in the lower reaches of both the Amu Darya and the Syr Darya by the diversion of much of the flow for irrigation, so that minimum flow rates in the lower reaches of the main rivers may occur in late summer. Flow rates in sections of the system may also be modified by operation of the large reservoirs for hydroelectric generation purposes, which has resulted in large winter flows in recent years. The timing of reservoir operation for these purposes is governed by interstate agreements.

21. Allocations of main stem flows are made by the ICWC every three months, after review of past allocations and forecasts of future available resources. The proportional allocations, averaged over the period 1993-94 to 1998-99, for both basins are shown in Table 2.

Table 2: Allocation of Main Stem Flows (%) in Period from 1993-94 to 1998-99

Country	Syr Darya Basin		Amu Darya Basin	
	Allocation	Limit	Allocation	Limit
Kazakhstan	38.3	42.0	-	-
Kyrgyzstan	0.8	0.5	1.0	0.6
Tadjikistan	9.1	7.0	17.9	15.4
Turkmenistan	-	-	39.3	35.8
Uzbekistan	51.8	50.5	41.8	48.2
Total	100.0	100.0	100.0	100.0

22. 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 regional 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.

2.1.2 Groundwater Resources

23. According to hydrogeological estimates the underground water sources in the Aral Sea Basin have a total annual potential yield of about 31.5 km^3. The distribution between the five countries of the available groundwater reserves, and the current usage of extracted water, is shown in Table 3.

Table 3: Groundwater Availability and Use in Year 2000 by Country (km^3/year)

Country	Regional Resources	Approved for Utilisation	Actually used in 2000	Purposes				
				Drinking Water Supply	Industrial	Irrigation	Vertical Drainage	Other
Kazakhstan	1.85	1.27	0.29	0.20	0.08	0	0	0.01
Kyrgyzstan	0.86	0.67	0.24	0.04	0.06	0.01	0	-
Tadjikistan	6.95	2.02	0.99	0.48	0.20	1.59	0	0.01
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	0.15
Total for the Aral Sea Basin	31.47	12.98	9.64	4.31	1.09	4.04	1.41	0.17

Source: NWG Reports

24. It can be seen that groundwater is a significant source of irrigation water only in Tadjikistan and 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.

2.1.3 Basin Water Balance

25. Studies by the Regional Working Group using all the available river flow and other data indicate that the total long-term average annual flow generated in the Aral Sea basin amounts to 116 km^3 (1960-2000). The total volume of water diverted from the rivers for irrigation amounts to average to about 100 km^3 per year recently, with

groundwater providing another 4 km^3 per year. The net domestic and industrial usage (from both surface and groundwater sources) totals about 10 km^3 per year.

26. A gross water balance for the Basin prepared from the modelling results is shown in Table 4. It shows how the total available water resources of the Basin are distributed among the various uses in 1999.

Table 4: Water Balance in the Aral Sea Basin in an Average Year in 1999

Resources	**km^3/year**
Surface water	118.62
Return drainage flows to rivers	27.52
Groundwater abstracted from aquifers	10.00
Total	146.15
Use	
Irrigation	100.48
Net domestic and industrial use (total use less returns)	10.00
Evaporation and other losses from reservoirs	5.46
Diverted to desert sinks	9.00
Reduction in storage	1.53
Losses from Amu Darya and Syr Darya main stem	15.40
Volume passing through wetlands and to Aral Sea	14.28
Total	146.15

27. Very large losses occur from the Amu Darya main stem, mainly in the section between the Karakum River diversion and Tuyumuyan Reservoir. These losses had been identified previously by SIC-ICWC and others. The losses are presumed to be largely seepage losses from the river bed into the underlying sediments.

2.2 Future Changes in Resources

28. 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 since monitoring started in the early 1900s. 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 likely 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.

29. 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 there will probably be less flow than now and greater variability.

3. PROBLEM ANALYSIS

3.1 Scope

30. This chapter of the report describes the major problems associated with the water resources sector in the Aral Sea Basin. The background to these problems is presented first, and the extent of the problems is then quantified where possible in terms of their physical magnitude and their economic impact.

31. The main problems that have been identified are:

- The shrinking of the Aral Sea, and the consequent effects in the areas around the original margins.
- High salinity levels in the lower reaches of the Amu Darya and Syr Darya, which affect the suitability of the water for domestic and industrial use and irrigation.
- The spread of shallow watertables under much of the irrigated area. Shallow watertables have a major impact on agricultural productivity and also affect rural and urban infrastructure.
- An increase in the proportion of irrigated lands in the Aral Sea Basin in which soil salinity levels are classed as ‘moderate’ or ‘severe’.
- Excessive water use in irrigation and in urban areas, and excessive water losses in the irrigation supply system and on farms.
- Difficulties in the management of the Basin water resources due to conflicts of interest between the irrigation and electricity generation sectors, and consequent differences in operational requirements between upstream and downstream countries.
- Shortages of finance for both rehabilitation and routine operation and maintenance of the water resources infrastructure.

3.2 Aral Sea Littoral and Delta Areas

32. The oases that spread out along the old caravan (silk) routes exploited the rivers from ancient times, and irrigation has a history of more than 2000 years. However, in the Soviet period water was diverted on a large scale from the rivers to steppe and desert areas, mainly for cotton cultivation. Huge dams were constructed and massive diversion structures, pumping stations and canals took the water to large-scale irrigation schemes.

33. The water diversions had (and have) huge impacts. Prior to 1960 the Aral Sea received around 60 km^3 annually, its surface area was 66,000 km^2, the water level was around 53 m BSL and the salt concentration 8 to 11 g/l. The Sea received in recent years on average only about 12 km^3 annually (8 km^3 from the Amu Darya and 4 km^3 from the Syr Darya). Water inflow reduced by 48 km^3 mainly due to water consumption increase in middle and lower reaches. The sea’s surface area has been reduced to less than 20,000 km^2, the water level has dropped to below 32 m BSL and the salt concentration has increased to over 60 g/l.

34. In 2003 the lake consisted of three compartments: an isolated part in the north (Northern Aral Sea or NAS) fed by the Syr Darya, and two main water bodies (Western Aral Sea or WAS, and Eastern Aral Sea or EAS; together referred to as Larger Aral Sea or LAS) fed by the Amu Darya. The WAS and EAS have recently disconnected from each other at the southern side.

35. Changes in hydrology and salinity resulted in a complete change in natural and socio-economic conditions around the lake. Fisheries disappeared in the LAS with unemployment as a result, the exposed lake bottom gave wind erosion with salt and chemical pollution of the surroundings, the local climate changed, biodiversity declined, etc. In the deltas, irrigated areas and in various other locations in the two river basins, problems related to water shortage, salinity and groundwater arose. The disintegration of the Soviet Union complicated the situation further.

36. Although the large-scale irrigation resulted in a huge increase in agricultural production and the construction of reservoirs provided hydropower and water for irrigation, both have led to many problems for humans, fauna and flora. These relate to the decline in the Aral Sea level, change in groundwater levels, salinisation, pollution, reduction in 'environmental flows', disappearance of economic resources, habitat destruction, and erosion and sedimentation.

37. Only about 8 km^3 per year of the Amu Darya water reaches the Larger Aral Sea, while about 4 km^3 per year of the Syr Darya water adds to the Northern Aral Sea. The water that reaches the Aral Sea has an average salinity of 1.0-1.1 g/l.

38. While groundwater levels have risen in and near the irrigated areas in the river deltas, elsewhere they have fallen. Lower water levels in the rivers cause lower groundwater tables in the adjacent areas, and the retreat of the Aral Sea has resulted in reduced watertable levels in the lower delta areas of the Amu and Syr Darya, close to the former Aral Sea shoreline.

39. With the shrinking of the Aral Sea, salts have accumulated on the former sea bottom, including sodium chloride and sodium sulphate. High concentrations of these salts are toxic to plants, particularly during flowering, and hinder the establishment of vegetation in these areas. Since 1975 storms around the period April-May in south-westerly direction (60% of the time) have picked up the polluted topsoil and deposited it in the Amu Darya delta and other parts of Karakalpakstan. Flora, fauna and human life have all suffered during and after these storms.

40. The poor economic situation in the Aral Sea region, mainly caused by the disappearance of the fish resources in the Aral Sea in the early 1980s that resulted in the collapse of the fishing industry, has led to pressure on the natural resources. Agriculture, hunting, fishing, reed cutting, wood collection, overgrazing and landscape alterations for irrigation purposes are not favourable for biodiversity. Decreased water availability has also led to a decline in the availability of these natural resources and thus to a reduced income for the population. A positive side-effect for ecology of the declining economy has been the reduction in the use of fertilisers, pesticides etc in irrigated agriculture.

41. Drinking water quality is a major problem in some areas. In northern Karakalpakstan, in the lower delta of the Amu Darya, groundwater levels have lowered with the retreat of the Aral Sea and people have resorted to the use of surface water, often of poor quality.

3.3 River Water Salinity

3.3.1 Current River Water Salinity Levels

42. The river waters generated in the mountain areas are of high quality, with salinity levels generally in the range 0.15 to 0.25 g/l. Salinity levels generally increase with progression downstream, as a result mainly of the salt load in the return flows from irrigated areas discharged via the collector drains. Thus, in the lower reaches of the two main rivers, there have been significant increases in salinity over time with the expansion of irrigation. Salinity levels have now stabilised, and in fact over the last decade (1991-2000) there has been a drop in mean annual values of salinity in the middle and lower reaches of both rivers. This is attributable to a decrease in drainage flows related to the changes in water management and economic conditions in the region, and also to the occurrence of higher-than-average flows in the past ten years.

43. Table 5 provides a broad indication of the present river salinity levels throughout the Basin. It shows average salinity levels over the period 1991-2000 and also the peak levels experienced over that period.

Table 5: Present Levels of River Salinity throughout the Aral Sea Basin

River	Location	Salinity Levels (g/l) during 1991-2000	
		Average	Peak
Amu Darya Basin			
Pyandj	Lower reaches	0.45	0.73
Vaksh	Lower reaches (Kurgan-Tyube)	0.78	0.93
Kafirnigan	Lower reaches (Tartki)	0.36	0.46
Amu Darya	Termez	0.63	0.98
	Atamurad (formerly Kerki)	0.74	2.4
	Ilchik	0.87	1.4
	Tuyamuyun	0.82	1.32
	Samanbay	1.05	2.23
Syr Darya Basin			
Naryn	Lower reaches (Uchkurgan)	0.31	0.6
Karadarya	Lower reaches (Uchtepe)	0.50	0.85
Syr Darya	d/s of Kairakkum Reservoir	1.10	1.22
	d/s of Chardara Reservoir	1.04	1.18
	Kyzyl-Orda	1.12	2.0
	Kazalinsk	1.14	2.8

d/s = downstream Source: RWG Report 'Assessment of Salinity and Chemical Structure of Syr Darya and Amu Darya Rivers', June 2001.

44. The table shows that peak salinity levels experienced in the Amu Darya main stem over the period 1991-2000 have ranged from over 1.0 g/l at the head to over 2.0 g/l in the lower reaches near the Aral Sea. In the Syr Darya the salinity levels experienced have peaked at over 1.2 g/l in the middle reaches and 2.8 g/l close to the Aral Sea.

45. Salinity levels fluctuate over the year in a fairly predictable fashion, varying inversely with river flow. Thus salinity levels in the lower reaches of the two main rivers tend to be highest in late summer and lowest in late spring.

46. Studies by the RWG, based on information from SANIIRI, indicate that at river salinity levels of 1.1 g/l, which apply in the delta areas – Khorezm, Dashovuz, and Karakalpakstan - the annual costs of average agricultural production are increased by roughly 10%.

47. The dominant cations in the waters of both major rivers are calcium and magnesium, particularly in the upper reaches where the concentration of these two ions together is about five times the sodium concentration. This dominance reduces progressively downstream, with the ratio being about one at the bottom. Sulphate is the dominant anion throughout the length of the rivers, the sulphate concentration being roughly two times the chloride concentration along the Amu Darya and more than three times in the Syr Darya.

48. As a result of the calcium-magnesium dominance, the waters of both the Amu Darya and the Syr Darya have a sodium adsorption ratio (SAR) of less than 6 at all points and under all conditions. SAR, which is a function of the relative concentration of sodium compared with calcium and magnesium, is an indicator of the tendency for dispersion of the soil particles and structural breakdown of the soil with consequent reduced infiltration capacity. A value of 6 for the SAR of applied irrigation water is generally accepted as being the minimum at which such problems are likely to occur. Thus no problems of soil sodicity would be expected to arise.

49. The dominance of calcium and sulphate in both rivers is highly significant, because these ions have less influence on the osmotic pressure of the soil solution than sodium and chloride ions. The salinity impact on crop growth and yield of irrigation water is likely to be less than would be indicated by most internationally-accepted salinity/yield loss relationships, which generally have been developed from research using waters in which sodium and chloride were the dominant ions. The relatively high salinity levels in the downstream reaches of the two rivers are likely to have little direct impact on crop yields.

50. The chemical composition, and particularly the ‘hardness’, of water is also important in relation to its use for domestic and industrial water supply. Water with a high level of hardness may leave a deposit (scale) on surfaces, particularly in heaters and boilers, and this tendency to deposit scale increases with hardness. The deposit, which typically contains calcium, can block fittings, reduce heat transference capacity, and shorten the effective lifetimes of equipment and appliances. The waters of both rivers typically have a high level of hardness, and therefore the above problems are likely to be significant.

3.3.2 Effects of River Salinity

Effects on Agricultural Crops

51. Average rather than peak values for river water salinity are the more important in regard to impacts on crop yields. The two main crops grown in the delta areas – cotton and rice – both have a relatively high tolerance to salinity, and theoretically even at current peak levels there should be no salinity-induced yield losses in cotton and only small losses in rice. The yield losses currently experienced in the downstream areas are due mainly to the presence over most of the irrigated area of saline shallow watertables rather than river water salinity.

52. Nevertheless, research by SANIIRI indicates that the use of river water with salinity levels above 1.0 g/l for a long time (5-10 years and more) in areas with poor drainage and without leaching will lead to increased surface soil salinity and decreased productivity.

Effects on Domestic and Industrial Water Supplies

53. In regard to the use of water for domestic purposes, there may be costs associated with salinity in the water supply relating to increases in plumbing corrosion costs and the costs of repairs to, or the frequency of replacement of, hot water systems and other household appliances. Boilers and cooling towers are the main potential sources of cost relating to industrial water supply. The potential lies in the fact that the bleed (blowdown) from them is normally controlled, due to the salinity level, so an increase in salinity will lead to an increase in the volume bled off. The costs come from the cost of the additional water and also the cost of any chemicals in the water (used to control biological growths and/or scale) and the energy in the water (in the case of boilers). Another potential source of additional cost is where there is a need to desalinate boiler feed water or other industrial process water. Desalination costs are normally directly proportional to salinity. Public hot water supplies may also be affected by salinity in the water.

54. Local information indicates that there are relatively few plumbing fittings or water-using domestic appliances in typical households, and therefore large costs due to salinity would not be expected. Likewise, there are few industries in the downstream areas, and therefore salinity costs are expected to be of little significance.

Health and Aesthetic Aspects

55. Millions of people take their domestic and drinking water from the rivers or canals supplied from the rivers. The water supplied to the main cities in the downstream areas is treated to remove turbidity, although this has no effect on the salinity levels. The other supplies are untreated.

56. The maximum value for TDS (or TSS) according to Uzbekistan standards is 1,000 mg/l (or 1.0 g/l). This standard is the same as that of the World Health Organisation and the US EPA. Thus the fact that the average salinity level in the downstream reaches of the two rivers is about 1,100 mg/l in both cases, and that the peak levels are more than double that value, means that the consumers in the delta areas receive what is generally considered substandard water.

57. Since the waters in the downstream reaches of both rivers contain high sediment loads, and other pollutants and contaminants are sometimes present at significant levels, from both public health and aesthetic viewpoints there is a strong need for treatment of domestic supplies taken from the rivers. However, the effects of high values of TDS (as distinct from other pollutants) are of an aesthetic nature rather than a health problem. Taste and odour are the principal concerns, because at TDS levels higher than about 1,000 mg/l water has a discernible taste, which becomes more marked with increasing salinity.

58. Dissolved solids can be removed from water by various desalination methods. However, all of these are very costly, both to install and to run, and the introduction of some such form of desalination would impose a heavy financial burden on the area. In view of the other competing demands for funds in the Central Asian countries, it is doubtful if the high costs of desalination of river water could be justified on aesthetic grounds alone. The use of bottled drinking water may be a more acceptable alternative to those who could afford it.

59. Overall, from the economic viewpoint it appears that there are little in the way of health costs that are related to the levels of salinity in the two rivers. However, in the

downstream areas recurs is made to groundwater for drinking water supplies, but in dry years levels drop fast and the required capacity fails.

3.3.3 River Salinity Target

60. The overall conclusion to be drawn from the above is that, at current levels, river salinity has a limited economic impact on agriculture in the downstream areas. The losses experienced there are due principally to the presence of saline shallow watertables under most of the irrigated land and the associated urban areas.

61. However, since current average levels marginally exceed the limit for drinking water, and fluctuate to considerable above it, it is considered that a the target maximum level for strategic planning should be 1.0 g/l.

3.4 Shallow Watertables

3.4.1 Extent of Shallow Watertables

62. The watertable conditions in irrigated lands in the Aral Sea Basin are shown in Table 6 for 1990 and 1999.

Table 6: Irrigated Lands with Shallow Watertables

Planning Zone	1990 Irrigated Area ('000 ha)	Area with watertable < 2m ('000 ha)		% increase 1990 - 99
		1990	1999	
Syr Darya Basin				
Kyrgyzstan (total)	410	11	14	27
Uzbekistan				
Andijan	280	86	124	44
Djizak	290	13	24	85
Namangan-Syr Darya	30	25	31	24
Namangan-Naryn	240	39	42	8
Syr Darya Basin	290	61	105	72
Tashkent-Syr Darya	40	6	7	17
Tashkent-Chirchik	340	62	60	-3
Ferghana	350	121	173	43
Tadjikistan (total)	250	26	31	19
Kazakhstan (South)*	780	98	294	200
Total Syr Darya Basin	**3,300**	**548**	**905**	**65**
Amu Darya Basin				
Tadjikistan (total)	690	92	111	21
Uzbekistan				
Bukhara	330	62	62	0
Kashkadarya	190	5	4	-20
Karshi	290	5	3	-40
Navoi	120	28	40	43
Samarkand	400	37	48	30
Surkhandarya	320	16	19	19
Khorezm	250	192	234	22
Karakalpakstan (North)	140	107	128	20
Karakalpakstan (South)	360	218	263	21
Total Tadjikistan & Uzbekistan	3090	762	912	20
Turkmenistan				
Dashkovus	330**	182	238	31
Akhalsk	330**	43	107	149
Mary	370**	136	116	-15
Lebab	260**	162	187	15
Balkan	20**	5	6	20
Total Turkmenistan	1,310**	528	654	24
Total Amu Darya Basin	**4,400**	**1,290**	**1,566**	**21**

* 1994 ** Irrigated areas in Turkmenistan increased substantially between 1990 and 1999
Source: Jakubov, K. and Usmanov, A. RWG Report 'To Identify and Map Main Sources of Salt Generation', July 2001. Table 3.6.

63. The data indicate that the proportion of irrigated land with shallow watertables in the Aral Sea Basin increased from about 20% in 1990 to 30% by 1999. The rate of increase was greatest in the Syr Darya Basin.

64. In the Syr Darya Basin, the most rapid increase and the largest area with shallow watertables has occurred in Kazakhstan, with a 200% increase over the 10 years. This is mainly the Makhtaaral area in the Hunger Steppe. Other planning zones in the the Syr Darya Basin with rapid rates of increase and large resulting shallow watertable areas include Andijan, Syr Darya and Ferghana.

65. In the Amu Darya Basin, the most significant aspect is the very high proportion of irrigated land with shallow watertables in the Amu Darya delta areas of Khorezm and Karakalpakstan, where by 1999 80% of the irrigated area had shallow watertables.

3.4.2 Agricultural Losses Due to Shallow Watertables

66. Shallow watertables cause economic losses in a number of ways. The losses result from:

- yield reductions caused by unevenness of the soil surface,
- aquatic weed growth in the fields,
- bogging-down of tractors engaged in land preparation and crop operations,
- excessive compaction of the subsoil by machinery operations, which limits rooting depth and causes yield loss.
- the operational and water costs associated with making leaching applications, which are only necessary where there are shallow watertables
- the operation and maintenance costs of the drainage system, which again is only needed in areas with shallow watertables,
- the abandonment of developed irrigation land that has become too saline for viable farming operations.

67. Satellite observations show that many irrigated fields of crops in Central Asia have prominent bare patches, which often occupy a large proportion of the field area. An analysis of satellite imagery of a number of fields in the Hunger Steppe showed that bare patches in sample cotton fields averaged about 28% of the planted area. In the case of wheat fields the bare patches averaged 14% of the planted area. The impacts are due to (i) the effects of high soil salinity levels on germination and (ii) insufficient water to meet plant requirements because of a lack of water on the higher areas. Studies of a number of examples have shown that, in all cases, unevenness of the land was the cause of the bare patches. Overall, it is estimated that yield losses of about 25% occur as a result of this surface unevenness.

68. Reeds and other grasses that are normally confined to drainage collectors and waterlogged areas are occurring increasingly in fields of wheat and cotton where there are shallow watertables. To eliminate these weeds it is necessary to fallow the land for period of months and to cultivate it or spray herbicides. The costs include loss of production by the enforced fallow, and cultivation and/or spraying costs.

69. Inadequate cultivation results when tractors become bogged down in fields where the watertable is less than one metre deep, particularly after irrigation or rainfall. As a result, land preparation is generally late and crop operations are delayed or omitted, with consequent reductions in crop yield.

70. Subsoil compaction occurs with the passage of machinery over soils when they are moist. The compacted layer limits root growth and the uptake of nutrients, and consequently has a depressing effect on crop yields. The presence of watertables close to the surface increases the length of time during which high levels of soil moisture occur, thus exacerbating the situation.

71. The presence of shallow watertables in most cases brings with it the need to leach the soil before planting a crop. Consequently, the value of the leaching water used is a cost attributable to shallow watertables. The use of leaching water is estimated to average about 1,200 m^3/ha of irrigated land.

72. Drainage systems are generally only essential where shallow watertables occur. The costs of operating and maintaining these systems are therefore attributable to shallow watertables.

73. It is estimated that between 450,000 ha and 620,000 ha of formerly irrigable land throughout the Aral Sea Basin are currently not used or have been abandoned for cultivation of irrigated crops in the last 10 years. The most likely explanations for the abandonment are

- Lack of incentives for farmers;
- Increase of soil salinity;
- Shortage of other production resources (agricultural machinery, fuel, agricultural chemicals and others).

74. When water losses are reduced (by decreasing operational and conveyance water losses in the supply system) and other major shortages in other production resources are solved, part of the unused areas could be returned into agricultural production. However, the return of highly saline areas into agricultural production is problematic.

75. The sensitivity of plants to salt varies with both age and species. The most tolerant plants include: cotton, sugar-beet, and some forage grasses, while most vegetables, clovers and fruit trees are the most sensitive. However, most salt-tolerant crops are as sensitive as the other crops during the germination and early growth phases. The value of the losses in crop yield caused by soil salinity has been derived using FAO relationships between salinity and yield loss applied to the areas with various levels of soil salinity.

76. Estimates of the economic values of these losses derived by the RWG are presented in Table 7. The valuations are based on the average farm gate economic price of the main crop commodities and the cropping pattern for each state.

Table 7: Estimates of Total Agricultural Losses ($US million/year)

Republic/River Basin	**Value of crop loss due to**						**Economic cost of leaching water**	**O&M cost of drainage system[3/]**	**Value of land abandoned due to salinity**	**Total losses ($Mil /year)**	**Total value of potential gross output [2/]**
	Bare patches due to:		Soil salinity on crop	Weed control	Inadequate cultivation	Soil compaction					
	Inadequate water	Soil salinity[4]									
Kazakhstan	91	61	8	17	4	11	11	0	3	**206**	606
Kyrghyzstan	42	28	1	0	0	0	9	0	0	**81**	278
Tajikistan (S)	26	18	0	2	0	2	9	0	0	**58**	177
Uzbekistan (S)	196	130	9	14	2	20	11	5	4	**390**	1 303
Syr Darya Basin	355	236	18	34	6	33	40	6	8	**735**	2 365
Tadjikistan (A)	56	38	1	3	1	3	9	0	0	**112**	376
Turkmenistan	169	112	22	14	2	16	27	3	14	**378**	1 124
Uzbekistan (A)	247	165	17	20	3	25	40	5	8	**529**	1 647
Amu Darya Basin	472	315	39	37	5	43	76	8	22	**1 019**	3 147
Aral Sea Basin	827	551	57	70	12	76	117	14	30	**1 754**	5 512

1. Crop losses are the estimated loss of potential yield x economic price weighted by the average cropping pattern in each republic after adjusting potential yield by average crop cover, expressed in prices x crop area
2. Gross output is the estimated potential value of crop production; ie. potential crop yield x economic price, weighted by the average cropping pattern in each republic
3. Source: Republic budgets for drainage 1999
4. Assuming 40% of losses in bare patches are due to soil salinity.

77. Thus, on the assumptions made, the total cost of shallow watertables and secondary salinity to the national economies over the whole basin is estimated at about $US 1,750 million annually, or about 32% of the economic value of potential crop

production. The extent of the losses is greater in the Amu Darya basin and less in the Syr Darya basin.

78. The costs due to bare patches in the field, which are the result of soil salinity and uneven watering, make up the bulk of the loss. The direct cause of these costs is unevenness of the field surfaces, which causes saline patches. Overall, the annual costs of secondary salinity estimated using the above methodology and assumptions amount to about $US 600 million. This estimate is in reasonable agreement with another estimate of the value of salinity losses in the Aral Sea Basin produced by the RWG, based on published salinity loss functions of the Uzbekistan Institute of Soil Science and Agrochemistry. This second estimate indicates losses in the whole Basin totalling $US 800-900 million annually.

79. The economic cost of leaching water is shown to be the next largest single cost at about 2.1% for the basin overall and about 5.4% in Tadjikistan. The smallest costs are the losses due to tractors bogging down, and the operation and maintenance costs of drains and collectors.

3.4.3 Infrastructure Costs due to Shallow Watertables

80. Shallow watertables in irrigated areas have a considerable impact on road life and road maintenance requirements, and cause significant costs. The costs are due mainly to the saturation of the road pavement, which reduces pavement strength and increases the incidence of pavement failure. The salt in the groundwater can also have an effect.

81. The existence of shallow watertable conditions is likely to increase the costs of all types of infrastructure constructed below ground level because of a greater need for dewatering during construction and, later, more potential for corrosion. This applies to water and gas pipelines and telephone lines/conduits, and also items requiring excavation for foundations such as transmission poles and towers, bridges and other structures. The construction of new buildings, particularly where it involves deep excavation for cellars etc., is similarly likely to be affected. In particular, the high sulphate levels generally occurring in groundwaters in the Basin would have a corrosive effect on concrete structures, although information from the BVOs is to the effect that in recent years sulphate-resistant cements have been used in most hydraulic structures to obviate such effects. Sulphates in the groundwater also cause loess soils to slump, leading to instances of building subsidence.

82. Maintenance costs are also likely to be increased by the presence of shallow watertables, and these costs may increase with increasing salinity of the groundwater. This is particularly the case with buildings of historic and architectural importance such as ancient mosques, medressas and mausoleums.

3.5 Soil Salinity

83. Salt occurs naturally in all soils, having been deposited there during deposition of the sediments. Much of the salt is originally located well below the surface and in the groundwater, and it presents no problem while watertables are well below the surface. However, where lands are irrigated there is usually an excess of water passing below the root zone, and this eventually causes watertables to rise. Where the watertable rises to within about 2 m from the land surface, groundwater is drawn by capillary action to the surface where it evaporates, leaving any contained salt behind (termed 'secondary

salinisation'). Accumulation of this salt over time leads to high soil salinity levels in the root zone, and these affect plant growth to varying degrees depending on the tolerance of the plant. Salt at the surface may be washed off into the drainage system, or the groundwater may enter the drainage system directly. In either case the salt, which was once at a safe level below surface, has been 'mobilised' and has the potential for harm, both where it originates and further downstream.

84. Local classification of soil salinity is commonly based on the percentage of salts in the soil and on chloride concentration. The measurement of Total Toxic Salts and sodium concentration are also used. Soil salinity levels are categorised in terms of five ranges: non-saline, and slightly, moderately, severely and very severely saline. Limits to these ranges vary depending on pH and the chloride:sulphate balance.

85. The prevalence of moderately and severely saline soils (according to local methods of classification) is shown in Table 8.

Table 8: Areas of moderately and severely salinised lands in irrigated areas (1990 – 1999)

Planning Zone	1990 Irrigated Area ('000 ha)	Area with moderate or severe soil salinisation ('000 ha)		% increase 1990-99
		1990	1999	
Syr Darya Basin				
Kyrgyzstan (total)	410	9.1	8.4	-8
Uzbekistan (total)	1860	199	330	66
Andijan	280	3.0	12.3	310
Djizak	290	90	103	14
Namangan-Syr Darya	30	2.4	8.4	250
Namangan-Naryn	240	2.5	4.5	80
Syr Darya	290	58	104	79
Tashkent-Syr Darya	40	0.3	0.3	0
Tashkent-Chirchik	340	1.1	1.2	9
Ferghana	350	41.5	96	132
Tadjikistan (total)	250	15.3	54	253
Kazakhstan (South)	780	119*	215	80
Total Syr Darya Basin	**3300**	342	608	78
Amu Darya Basin				
Tadjikistan (total)	690	18.6	18.5	0
Uzbekistan (total)	2400	505	638	26
Bukhara	330	90	103	14
Kashkadarya	190	13.4	15.6	16
Karshi	290	43.6	45.5	4
Navoi	120	25.1	41.9	67
Samarkand	400	5.6	5.4	-4
Surkhandarya	320	44.1	60.7	37
Khorezm	250	100	148	48
Karakalpakstan (South)	140	51	66	30
Karakalpakstan (North)	360	132	151	15
Total Tadjikistan & Uzbekistan	3090	524	656	26
Turkmenistan (total)	1310	636	1166	83
Dashkovus	330**	219	360	64
Akhalsk	330**	162	381	135
Mary	370**	138	214	55
Lebab	260**	103	135	31
Balkan	20**	14	76	443
Total Amu Darya Basin	**4400**	**1160**	1822	57

* 1994
** Irrigated areas in Turkmenistan increased substantially between 1990 and 1999.
Source: Jakubov, K. and Usmanov, A. RWG Report 'To Identify and Map Main Sources of Salt Generation', July 2001. Table 3.5.

86. The table shows that the proportion of irrigated lands in the Aral Sea Basin in which salinity levels classed as 'moderate' or 'severe' occurred in the top metre of soil has increased substantially in recent years, with 30% of the whole irrigated area in the Basin falling into those classes in 1999. This represented an increase of 62% between 1990 and 1999.

87. Considering firstly the Syr Darya Basin, it is evident that soil salinity problems are minimal in Kyrgyzstan, and appear not to be increasing in extent there. However, the problem appears to be increasing rapidly in Tadjikistan. In Uzbekistan as a whole, the area classed as moderately or severely saline has increased by over 60% since 1990, and in 1999 amounted to 18% of the total irrigated area. The high salinity areas were concentrated mainly in three planning zones: Djizak, Syr Darya and Ferghana, i.e. the Hunger Steppe and the southern part of the Ferghana Valley. In Kazakhstan the proportion affected amounted to 28% of the total, with a large increase from 1990. Much of this area was also in the Hunger Steppe (Maktaaral rayon).

88. In the Amu Darya Basin, there appear to be minimal problems in Tadjikistan, and no indication of any significant increases there. In Uzbekistan, two planning zones in the upper and middle reaches – Bukhara and Navoi – contain relatively large areas with moderate or severe salinisation, and in the latter in particular the area is increasing in size at a significant rate. In Surkhandarya about 20% of the irrigated area is salinised, and the extent is increasing at a significant rate. All zones in the delta area – Khorezm and north and south Karakalpakstan, contain large areas with moderate or severe salinity levels and all are increasing in extent at a significant rate. The situation appears worst in Turkmenistan, where the data indicate that in some planning zones virtually all of the irrigated area is salinised. This may be misleading to some extent, because of uncertainty regarding the total area that is now irrigated, but there is no doubt that the areas both in the delta and along the Karakum River are heavily salinised.

3.6 Water Losses

3.6.1 Quantification of losses

89. The main water resource problem of the Aral Sea Basin is inefficient water management rather than shortage of water, although this may occur locally or during dry years. A large proportion of the water diverted from the main rivers for irrigation is lost in various ways before it can actually be applied to the crops, much of the loss being due to low levels of on-farm water management. Also, the liberal use of water that is a traditional part of life in urban areas results in per capita rates of consumption that are high on the world scale. There are considerable costs associated with this high consumption, including the capital cost of the infrastructure to supply the high demands, and also the costs of pumping and treating the water.

90. An indication of the low levels of water use efficiency that currently apply throughout the Aral Sea Basin is provided by the data in Table 9, which shows the supply system and in-field efficiencies in several areas that are representative of conditions throughout the Basin.

Table 9: 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
Mountain-Badakhshan/ 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.

91. Losses of water in the irrigation distribution systems and on the farms obviously vary from place to place depending on many factors, including soil type, the condition of the infrastructure, operating conditions, and operating and management practices. Studies by the Regional Working Group indicate that, averaged over the Basin, the losses and/or consumption of water abstracted for irrigation are as follows:

Table 10: Water Losses and Use

		Volume (m^3/ha/year)	% of offtake volume
Main and inter-farm conveyance losses (including evaporation)		3,230	25
On-farm canals:	- conveyance losses	3,100	24
	- operational losses	3,100	24
In-field water use:	- leaching and land preparation	770	6
	- irrigation	2,700	21
Total		12,900	100

92. These figures indicate that very high losses occur throughout the system and that only a small proportion of the diverted water is usefully used. In all a total of about 40% of the water diverted from the rivers is estimated to be lost by seepage from the canal system. Of this, about one third is probably lost from the main and inter-farm system and two thirds from on-farm canals. Including assumed reuse of drainage water for irrigation, the overall hydraulic efficiency of the system at present is shown to be about 60%, which is well below the 75% used in the design of schemes. The studies also indicate that roughly 60% of the total accessions to the groundwater come from seepage from main, inter-farm and on-farm canals, and the other 40% from seepage during leaching and irrigation.

93. There is obviously scope for substantial increases in water use efficiency, particularly at the farm level. Not all the volume shown as 'losses' is in fact wasted -

seepage water enters the groundwater, which contributes to a large part of the crop requirements, and much of the water entering the drains is reused or is returned to the rivers and is available for use downstream. However, the fact that much of water diverted from the rivers is lost from the canal systems suggests strongly that measures in that sector are likely to prove the most viable. This is likely to be the case particularly where considerable costs are involved in supplying the water, such as where there are high pumping heads.

Main and Inter-farm Canal Losses

94. Less than 30% of the main and inter-farm canal system in the Aral Sea Basin is lined, and losses due to seepage through the canal sides and beds are obviously significant. Other losses are likely to be of an operational nature in the form of spills or 'escapes' from the canal system, either directly back to the source river or into the collector drainage system. In the latter case, the spills may return to the river for reuse, or may be diverted to evaporation basins ('desert sinks') in which case the water is lost as a resource. Due to high salinity of drainage water, approximately 40% of drainage water is diverted to desert sinks.

Losses in Farm Canals

95. Only a small minority of on-farm canals are concrete lined and there is considerable seepage from them, particularly in areas with relatively permeable soils. Many of the canalettes have corroded as a result of high sulphate concentrations in the waters, and this has resulted in the complete or partial collapse of many support structures and canal linings. There is substantial leakage from the collapsed systems, and in many places the canalettes have been replaced by pipes or earth canals.

96. In regard to operational losses, most canal systems were never equipped with sufficient control structures and measuring devices for efficient management, and those that exist are largely inoperable. As a result of these problems, a large proportion of the water in the canals is discharged directly into the drains. There are now also many unauthorised offtakes from canals for a variety of reasons.

Field Irrigation Losses

97. Generally the standards of field water management are very low, as has been noted by several observers. In one example, the water profile in a field was found to have filled up 5 hours after the commencement of irrigation, but irrigation continued for another 43 hours. It was concluded that the field was 'massively over-watered, with most of the water being wasted.' In other studies, application efficiency levels for wheat were assessed to be less than 40% compared with a desirable level of about 75%.

98. Much of this is due to the lack of incentives for farmers to improve efficiency. Partly it is due to incorrect furrow length and inadequate furrow flow rates, in turn resulting from a lack of knowledge and training on the part of the farmers.

3.7 Transboundary Waters

99. The agreement on 'Cooperation in the sphere of joint management of use and conservation of water resources of interstate use' (Almaty, 18 February 1992) 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. Subsequently, codification of transboundary waters and the facilities on transboundary waters can be undertaken. The project has addressed these issues, and proposals are in Section 4.6.

3.8 Financing

100. In accordance with the agreed allocation of the waters of the Amu Darya, Turkmenistan and Uzbekistan contribute equally to the financing of the BVO Amu Darya. Kyrgyzstan does not contribute in view of its small allocation, while Tadjikistan finances Kurgantube hydrostructure management authority of BVO “Amu Darya” and maintenance and repair of its headworks. Khodjant and Isfarin branches of BVO “Syr Darya” are also financed by the Republic of Tadjikistan. Most operating activities of the BVOs are therefore financed from the budget allocations from Turkmenistan and Uzbekistan. Generally about 90-95% of the funds is expended on direct operational costs, including current repairs, and less than 10% on capital repairs and purchase of equipment and machinery. As a result, much of the necessary refurbishment or replacement of infrastructure items has not been carried out, and many of these items are in an advanced state of deterioration.

101. Funding for BVO Syr Darya is also to be provided in accordance with water allocations, but in recent years only Uzbekistan has regularly provided its full share. Because of this, the necessary capital and current repairs have not been carried out fully and the condition of the infrastructure has deteriorated.

4. SOLUTION ANALYSIS AND PRIORITY SETTING

4.1 Demand Management

4.1.1 Definition

102. In the water resources sector the primary management aim is to match the supply with the demand. As populations increase with time and demands start to exceed the available supply capacity, the need arises for action to bring the two back into balance. The achievement of this aim can be approached from two directions:

- Increasing the available capacity i.e. managing the supply side of the equation (termed 'Supply Management')
- Constraining demands so that they remain within the available supply capacity i.e. managing the demand side of the equation ('Demand Management')

103. Supply Management is usually the automatic response when an out-of-balance situation becomes evident. More dams are built, bigger pipelines are constructed, and the system is expanded generally to meet the forecast demands, which are usually calculated on the basis of past experience. However, the costs of augmenting the supply system usually rise at a much greater rate than the demands themselves, because generally the closest and least expensive sources of water and/or dam sites are developed first, and later ones become much more costly. Eventually the situation is reached where people are willing to accept constraints on their usage in preference to the increase in taxes necessary to augment supplies.

104. In the case of the Aral Sea Basin, there is a great need for funds to rehabilitate infrastructure, not only in the water resources sector but throughout the whole economy. In the light of the resulting competition for funding, 'Demand Management' is the obvious approach to be adopted in the water resource sector.

105. A World Bank policy paper on water resource management defines Demand Management as "the use of price, quantitative restrictions, and other devices to limit the demands for water." To be successful, Demand Management requires good communication between the supply managers and the consumers, so that the consumers fully understand the problems, possible options, and the rationale for the constraints on their consumption. The existence of a market economy with associated financial incentives generally greatly enhances the impact.

4.1.2 Demand Management Options

106. Demand Management is essentially a matter of increasing the efficiency of water use, that is, reducing wastage. Apart from reducing conveyance losses, which is generally a technical matter that is directly the responsibility of the relevant water supply authority, the ways in which demands can be constrained in both sectors include:

- Pricing or tariff measures
- Education/raising public awareness
- Introduction and promotion of water-saving technologies
- Introduction and enforcement of limits on water use (water restrictions).

- Operational improvements

107. The first four, which are directed at consumers, are best implemented as a package involving both incentives and sanctions. The fifth, which is the province of the supply authorities, can be carried out independent of other measures.

Pricing or Tariff Measures

108. Although water itself comes from the heavens and the use of it can be considered a fundamental right, in a developed society the infrastructure for delivering that water requires considerable expenditure, and ultimately the community has to pay for that delivery. This can come about in an indirect way, with the delivery costs being met from government funding (i.e. subsidisation), or by a direct charge to the consumer. In the first case the consumer does not perceive any link between his water usage and his tax levels, and thus there is no incentive to minimise consumption. However, in the second case, if the supply tariff is structured appropriately, then a strong message can be delivered on the benefits of minimising wastage.

109. The important principle is that water should be charged for on the basis of volumetric measurement i.e. the cost should be directly proportional to the amount used. The incentive to minimise consumption is then obvious and clear.

Education/Raising Public Awareness

110. A lot can be achieved in reducing the wastage of water by education and the use of the media to promote good water use practices. Direct education and training of the farmers is the primary tool in the case of irrigation, while in the case of municipal water supply, the use of the media to the general public is the more important.

Water-saving Technologies

111. There are many technologies available to reduce wastage in both irrigation and municipal water supply. In the irrigation field, they include a number of seepage reduction techniques to reduce canal losses. Apart from improving current irrigation practices, there are also many on-farm water management techniques available, including different application methods such as drip and micro-spray irrigation, laser land levelling, and the use of soil moisture monitoring devices.

Operational Improvements

112. Significant improvements in the ways in which the water supply systems are operated can often be achieved, in some cases by more human input and in others by greater use of technology. An example is the control of irrigation canal flows, which with better measuring and control equipment can be more accurately tailored to demands, with less water spilled to waste.

Restrictions on Water Use

113. A fundamental approach to an incipient water supply shortage is to introduce restrictions on the use of water. In the case of municipal water supply, these can be structured in a graduated form, increasing in severity as the water supply situation deteriorates. The degree of restriction can be tailored to the circumstances. The involvement of the media is essential for this approach to be successful, so that everyone is made aware of the restrictions, and also the reasons for them.

114. A similar graduated form of restrictions is not practicable in the case of irrigation. It might be possible, however, to set limits to the amount of water to be used, and to supply only that volume. If the limits were set at relatively low levels, this would probably provide a strong incentive to minimise wastage. This approach could be adopted until free market conditions become fully established and farm incomes rise sufficiently to allow realistic water charges.

4.1.3 Effects of Water Management Improvements

Reduced On-farm Seepage

115. 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 from 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 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.

116. 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.

117. Reductions in in-field seepage will be achieved mainly by better on-farm water management, which will involve relatively small expenditure on the refurbishment of existing measurement and control structures, the provision of new ones, and training and greater labour inputs to the operations process. 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. Reductions in channel seepage are likely to involve much greater expenditure per unit volume of water saved, and are unlikely to be a significant factor in increasing the available resource in the first 10 years.

Reduced Drainage Water Volumes

118. The other major source of loss of water is in the desert sinks. 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, where much of it evaporates or seeps away. In the Syr Darya basin the proportion discharged to sinks is 25%. It is clear that, if the rate of generation of drainage water is reduced, the volume lost in the desert sinks will also be reduced.

119. Much of the drainage water generated in the irrigated areas originates as overflows (or escape water) from the canal systems, leakage from on-farm canals, and over-watering of the fields. In the earlier irrigation developments in Central Asia the salinity of the drainage water was relatively low, and return of the drainage water to the river system via the collectors had little impact on the river salinity levels. Basically, the drainage water was mixed with river water and reused, the total volume of the overall Basin water resource was not affected, and the volume of drainage water generated was

therefore not an issue. However, the drainage water originating in later schemes is generally much more saline (often over 3 g/l), and hence it was found necessary to dispose of it to the desert sinks to avoid adverse effects on river salinity levels. The later irrigation schemes often involve pumped supplies, and the wastage of energy in pumping water which is later discharged back to the river system or disposed of by evaporation is obviously another important issue.

120. The average generation rate for drainage water in the Aral Sea Basin is about 5,000 m^3/ha annually. Experience elsewhere in the world shows that a reduction to 3,000 m^3/ha should be possible by upgrading canal systems and introducing better water management (both on-farm and off-farm) i.e. a reduction of about 40%. This would, however, require substantial investments in both the main and on-farm irrigation infrastructure. The estimated reductions in the volumes disposed of in desert sinks, and the corresponding increase in available water resource, that would result from the reduction in drainage flows is estimated to amount to 5.1 km^3 per year, are shown in Table 11.

Table 11: Potential Reductions in Volumes Disposed of in Desert Sinks with 40% Reduction in Drainage Flows

Sink	Reduction in Volume (km^3/year)
Uzbekistan	
Arnasay	1.00
Atchinsk	0.01
Ayakagitma	0.05
Daukhana	0.01
Dengizkul	0.29
Karakir	0.10
Khodicha	0.03
Total for Uzbekistan	1.49
Turkmenistan	
Turkmen Lake of the Golden Age	3.40
Kazakhstan	
Sinks	0.20
Total	**5.09**

121. With decreased drainage flows should also come a reduction in the problems presently experienced with some of the desert sinks (e.g. Dengizkul and Karakir), where inflows have had to be reduced or terminated because of flooding of adjacent land and nearby gas fields. With the reductions in the volumes of drainage water it would be possible to dispose of a greater proportion in the desert sinks, thus introducing the possibility of deferring the need for the $US 1,000 million Uzbekistan Right Bank Collector scheme or eliminating it altogether.

4.2 Sanitary and Environmental Flow Requirements

4.2.1 Main Ecological Components and Inflows to the Aral Sea

122. There are three main components to the ecological water requirements of the Aral Sea basin:

- those of the two rivers, including the upper, middle and lower reaches;

- those of their associated water bodies and wetlands, and
- those of the Aral Sea itself.

123. 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. In 2002 the Western Aral Sea and the Eastern Aral Sea disconnected from each other at the southern side.

124. The inflow to the Aral Sea varies considerably from year to year, depending mainly on conditions in the catchments. The annual average volume of Amu Darya water reaching the Larger Aral Sea 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 annual average volume of Syr Darya water discharged to the Northern Aral Sea is about 3.6 km^3 (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 2003 is over 60 g/l. The salinity in Northern Aral Sea is currently about 13 g/l and therefore at the limit of threat for biodiversity of these parts of the Sea.

125. Sanitary flows in the river channels are essential to maintain rivers as water objects, which have natural and social value; in particular, they are necessary to prevent worsening of the sanitary situation and degradation of river water quality. Ecological flows in the rivers are essential to maintain water related ecological systems. Sanitary-ecological flows are supplied to the irrigation network mainly for the purpose of meeting the household and drinking water demands of the population and secondly for the purpose of maintaining minimal water volumes in canals.

4.2.2 Values of lower river reaches, wetlands and the Aral Sea

126. 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.

127. 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.

128. 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.

129. 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.

4.2.3 Environmental Requirements

130. An agreed volume (preferably a fixed percentage of the national allocations) of water should be allocated for sustainable environmental purposes in the delta-wetland-ecosystems and the Aral Sea. The salinity of the Aral Sea or its remaining parts should be restored below 11 g/l for a healthy aquatic life. Above this 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. The salinity of wetland-ecosystems and lakes should remain below 5 g/l to guarantee sufficient habitat for aquatic species and waterfowl, and to guarantee availability of natural resources for the population (fish, reed, muskrats).

131. 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 gradually be reduced . 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 fixed inflow of 15 km^3 per year to the Western Aral Sea, the salinity level would fall to 11 g/l after about 30 years. With an inflow of 12 km^3 per year that limit would be reached in about 45 years.

132. Amu Darya flow into its delta should be at least 18 km^3 annually, 3 km^3/year (net) for the Amu Darya wetland-ecosystems, and 15 km^3/year for Western part of Larger Aral Sea. These environmental flow requirements to the wetlands, floodplains and lakes should preferably be released from Tuyamayun reservoir in the period April to August.

133. Syr Darya flow into its delta should be at least 8 km^3 annually for the same reasons, 3 km^3/year for Syr Darya wetland-ecosystems, and 5 km^3/year for Northern Aral Sea. Environmental flows to the wetlands, floodplains and lakes should preferably be released from Chardara reservoir in the period April to August.

134. SIC-ICWC has developed seasonal specifications for the sanitary flow. These volumes, although considered separately, would also be part of the flows needed to maintain the wetland eco-systems and the flows to the Aral Sea. Volumes of the required sanitary flows in the lower reaches of Amu Darya and Syr Darya rivers (90% probability) are:

Table 12: Seasonal Sanitary Flow Requirements

Sanitary flow (km3)	Amu Darya		Syr Darya	
	April - September	October - March	April- September	October - March
Required sanitary flow	2.7	0.8	1.0	0.6

135. Since the Aral Sea is recognized as a sixth independent water user in the Aral Sea basin but without a voice, it is preferable that the five states jointly ensure that the environmental water demands are met.

136. It is realized that such a situation would still take many years to achieve but should be regarded as a principle long-term objective for the States. In the long term, the potential water savings achievable through rational water use measures would provide for the required downstream environmental flow requirements.

4.3 Rational Water Use And Water Productivity

4.3.1 Importance of Priority Setting

137. In terms of risk management, the imminent collapse of a main structure, which threatens the livelihood of thousands of people, has the highest priority. Emergency repairs clearly deserve to be on the top of the list for expenditure, and economic evaluations are unnecessary as the outcome is a foregone conclusion.

138. However, for expenditure on less urgent matters, such as the repair and rehabilitation of irrigation and drainage infrastructure, there is likely in most Central Asian countries to be a shortage of available capital. There is an obvious need to consider the various alternative measures in a structured fashion that attaches priorities to them according to appropriate criteria. These would generally be economic criteria, although social and/or environmental criteria may be appropriate in some cases. As an example, it may be the case that targeting on-farm losses would provide a substantially greater return than reducing canal conveyance losses. In such a case the funding of training schemes and the provision of technical assistance would logically have the higher priority.

139. This describes studies by the Regional Working Group involving evaluation of various measures in a number of areas representative of conditions throughout the Aral Sea Basin. They include on-farm measures and main and inter-farm canal rehabilitation. Also included is an evaluation of new lands development.

4.3.2 On-farm Measures

140. The evaluation of on-farm measures to improve water use, and to improve the productivity of irrigated agriculture, has been a major task of the Regional Working Group. The evaluation is the subject of a substantial working paper entitled ‘Water Losses and Development Strategies’ dated February 2002. This describes:

- the methodology of estimating water use and losses
- losses in the irrigation system
- methodology for simplifying farm descriptions
- the various options to improve water productivity
- the economic analysis of the options.

141. It is necessary to note that the assessments and options stated below on improvement of water use and productivity are not exhaustive. In conditions, when agricultural reform is not yet completed, there could be changes in approaches to measures especially for farm types. For example, according to the information of the specialists of Uzbekistan, in a number of oblasts including Hungry steppe, at the first

stage since 2003, 176 large-scale farms and commercial branches (shirkat farms) will be liquidated and small-scale farms are being created. It already changes farm types and approaches to improvement of water use, as each farmer will compare measures with his capabilities. Besides, options suggested do not fully cover all the variety of measures (e.g. organizational, economic methods etc.) and/or set of measures.

142. Some options may be applicable only under certain conditions and in certain types of farms. Variables that may have an impact on this applicability include agro-climatic factors, altitude, latitude, soil type, and whether the farm is a small subsistence farm or a commercial farm. Eleven farm types comprising different combinations of these variables have been identified as the most relevant (Table 13).

Table 13: Identified Farm Types

Farm type code	1	2	3	4	5	6	7	11	8	9	10	Total/ Wtd. Av.
Zone 1	Mount	N Pied	S Pied	N M-P	N M-P	S M-P	S M-P	S M-P	L-P	L-P	L-P	
Altitude (m)	>1500	800-1500		200-800		200-800		2-300		<200		
Northing (^{o}N)	all	>41	<41	>41		<41		<40		>41		
Days >15 ^{o}C	<70	70-87	70-95	87-100		95-132		120		79-94		
Rainfall (annual in mm)	500	300	300	155	155	230	230	177	108	108	108	**199**
ETo (annual total in mm)	900	1,000	1,200	1,540	1,540	1,330	1,330	1,330	1,250	1,250	1,250	**1,312**
Typical soil texture class 2	SL	L	L	ZL	ZL	ZL	ZL	ZL	ZL	ZL	ZC	
Salt flux to rootzone (t/ha/yr)	0	0	0	0.4	0.4	12	12	97	10	10	114	**22**
Salinity	none	none	none	none	none	slight	slight	strong	mod	mod	strong	
Type farming	subs	subs	subs	subs	comm	subs	comm	comm	subs	comm	comm	
Irrigated area ('000ha)	152	83	252	652			4,525			1,835		**7,499**
Proportion of area (%)	100	100	100	50	50	20	70	10	30	40	30	
Irrig. area by code ('000ha)	152	83	252	326	326	905	3,168	453	551	734	551	**7,499**

Mount: mountains; N pied: Northern piedmount; S pied: Southern piedmount; NMP: Northern midplains; SMP Southern midplains; LP: Lower plains
SL: sandy loam; L : loam; ZL: silty loam, ZC: silty clay

143. The farm sizes are stylised, with farms in mountain areas being set at 0.2 ha, the size of an irrigated household plot, while the size of subsistence farms is taken as 5 ha in the former kolkhozes of the irrigated plains. For the purposes of the study the size of commercial farms has been taken to be 50 ha, which is the average size of a brigade unit, without regard to whether or not the unit has been 'privatised' or is still part of a kolkhoz. Typical cropping patterns are assumed for each farm type, taken from WUFMAS data.

- Large parts of the Planning Zones Kyzyl Kum, ARTUR, Chakir and Tashkent Chirchik are represented by farm type No. 5.
- Farm type No.7 is representative for the Planning Zones Fergana (valley), Namangan, Andijan, Khodjent, Syr Darya, Samarkand, Djizak, Karshi and parts of Hunger Steppe.
- Planning Zone Navoi is represented by farm type 9.
- Large parts of the Planning Zones Kyzyl Orda, Karakalpakstan, Khorezm and Daskovus are represented by farm type No. 10.
- Farm type No.11 is representative for the Planning Zones Bukhara, Lebab, Mary, Akhalsk, Balkan and parts of Hunger Steppe.

144. Farm types 6, 7 and 11 account for about 60% of the irrigated land. They represent farms on the southern mid-plains (e.g. Karshi, Hunger Steppe), which is the main cotton-producing land, believed to be mostly still in large commercial units. Farm types 8, 9 and 10 represent farms in the delta area (e.g. Karakalpakstan, Khorezm, Kyzyl Orda) and make up 25% of the total irrigated area. Types 10 and 11 are those with high salinity and greatest yield losses, and therefore are considered the most relevant when evaluating drainage measures.

4.3.3 Options Evaluated

145. The various available options identified by the RWG are shown as a matrix in Table 14. The options generally comprise a 'package' consisting of the principal measure together with several other measures that are necessary for the full potential benefits to be gained. For example, to obtain the full benefits from laser land levelling, it will be necessary for water management and irrigation and agronomic practices to be improved. Likewise in the cases of drip and sprinkler irrigation. The costs of these ancillary measures are included in the overall option costs. Options for water and land use improvement and productivity increase are not constrained to the options suggested. For instance, Tajikistan considers that introduction of the economic mechanism is one of the effective options for water saving and increase of its productivity. Kazakhstan pays attention to the efficiency of introducing the information – consulting systems, which will allow to provide not only rational use of water for irrigation but to also effectively manage the plant growth and crop formation.

146. All options except option 7 (reduced conveyance losses) include allowance for capital leaching.

Table 14: Summary of Options to Improve Water Use and Productivity

Option group	**In-field options**					**On-farm options**			
Option number	**1**	**2**	**3**	**4**	**5**	**6**	**8**	**7**	**8**
Option name	**Drip irrigation**	**Sprinkler irrigation**	**Land levelling**	**Traditional irrigation**	**Improved field drainage**	**Reduced operational losses**	**Improved farm drainage**	**Reduced conveyance losses**	**Improved farm drainage**
Case number	**7.1**	**7.2**	**7.3 9.3**	**7.4 9.4 9.5**	**10.5 11.5**	**7.6 9.6**	**7.8**	**5.7**	**10.8 11.8**
In-field works									
New irrigation system	Yes	Yes	No	No	No	No	No	No	No
Land levelling	No	No	Yes	No	Yes	No	No	No	No
Improved water management	Yes	Yes	Yes	Yes	Yes	No	No	No	No
Improved irrigation scheduling	Yes	Yes	Yes	Yes	Yes	No	No	No	No
Agronomic improved package	Yes	Yes	Yes	Yes	Yes	No	No	No	No
Rehabilitation of (or new) drainage systems	No	No	No	No	Yes	No	No	No	Yes
On-farm (FKS) works									
Improved management and reduced operational losses in canals	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
Reduced conveyancing losses in canals	No	No	No	No	No	No	No	Yes	No
Rehabilitation of (or new) drainage collectors	No	No	No	No	Yes	No	Yes	Yes	Yes

Option 1: Drip Irrigation

147. A capital cost of $4,000/ha has been assumed for the drip system, including the cost of storage. Land levelling would not be required in this option. However, improved scheduling and water management are implied, as water needs to be supplied at intervals of no longer than 3 days with a target application efficiency of 100%. Considerable changes in the management of the water supply system would therefore need to be made in this case.

Option 2: Sprinklers

148. The characteristics, advantages and constraints of sprinkler irrigation are much the same as in Option 1, but the technical options are much wider, ranging from plastic mini-sprinklers on plastic pipelines that are moved manually, to giant linear-roll and centre-pivot systems that are self-propelled. For the purpose of this evaluation, tractor-move, solid-set systems of sprinklers costing $1200/ha are assumed.

149. The selected irrigation system would need to apply water with the same irrigation intervals as surface irrigation, around 7 to 10 irrigations for summer crops, or about 14 day intervals, with a water saving of about 14%. Consequently some rehabilitation of the supply system (regulators, control gates etc) is assumed. No drainage improvements are assumed with this option.

Option 3: Land Levelling

150. This measure includes laser land levelling and deep ripping. The option does not include any drainage measures but, as in the previous two options, includes the improvements to on-farm water management, irrigation scheduling, and supply system management that would be necessary to provide irrigation supplies at the optimum times.

Option 4: Improving Traditional Irrigation

151. The option involves investing in the facilities to be able to reduce water losses in the field and to improve crop yields. It allows for the physical costs of improved water management at the farm level (rehabilitation of the supply system, such as gates and regulators), improved irrigation scheduling, and the agronomic package.

Option 5: Improved In-Field Drainage

152. The main element of this option is the rehabilitation and/or new installation of horizontal subsurface drainage, together with rehabilitation of farm collectors. It also includes land levelling, and the improvements to the management, irrigation scheduling, on-farm supply system, etc. included in the previous options.

Option 6: Reduced Operational Losses from On-Farm Canals

153. This option involves the rehabilitation of, or new, on-farm control structures, and new communications equipment and computer software. It also allows for a significant training effort to raise the standard of operation.

Option 7: Reduced Conveyance Losses in Farm Canals

154. This option involves rehabilitating canalette systems, replacing the lining of formerly lined canals, and lining earth canals.

Option 8: Improved Farm Drainage

155. This option includes the rehabilitation and/or new installation of horizontal subsurface drainage, together with rehabilitation of farm collectors. It does not include land levelling or other in-field or on-farm improvements.

156. A summary of the results of the economic analysis using a discount rate of 10% is provided in Table 15. The table also presents the results of sensitivity analyses to evaluate the impact of lower gross margins than assumed in the base analysis. The NPVs have been converted to a series of uniform annual amounts over the 25-year period.

Table 15: Economic Analysis of On-Farm Water Management Options

Option	Farm type	NPV ($/ha/yr) Scenario 3	BCR Scenario 3	IRR (%)		
				Scenario 3 (base)	Gross margin with option	
					at 75% of base	at 50% of base
Reduced conveyance losses	5	84	3.8	30	23	15
Drip irrigation	7	-265	0.7	3	-2	-10
Sprinkler irrigation	7	83	1.2	15	7	-4
Laser land levelling	7	208	2.3	27	18	8
Improved traditional irrigation	7	182	2.8	40	26	9
Reduced operational losses	7	13	1.2	14	1	-5
Improved farm drainage	7	-189	0.3	-25	-28	-31
Laser land levelling	9	94	1.5	18	12	5
Improved traditional irrigation	9	107	2.0	28	18	8
Reduced operational losses	9	9	1.1	12	5	-3
Improved field drainage	9	303	2.0	22	16	9
Improved farm drainage	9	-12	0.9	9	5	-1
Improved field drainage	10	281	1.7	23	18	12
Improved farm drainage	10	10	1.0	11	7	2
Improved field drainage	11	349	1.9	24	18	11
Improved farm drainage	11	-4	1.0	10	5	1

157. The results for farm type 5 indicate that reducing conveyance losses in on-farm canals in areas such as the piedmont zone in Tadjikistan would be the most economic option. This option involves repair of leaking canalettes and lined canals, with the benefits expected to arise principally from an increase in yields due to greater water availability and a reduction in pumping costs. This option, however, has relatively high initial capital costs, and is limited in its application.

158. In the main cotton-growing areas (farm type 7), both improved traditional irrigation and laser land levelling show high rates of return. Drip irrigation is shown to be uneconomic and sprinkler irrigation only just viable, due to the fact that the yield benefits are expected to be only marginally greater than those achievable using improved surface irrigation techniques. The analysis indicates that improved farm drainage in these areas would be highly uneconomic, while reducing operational losses would be only marginally viable.

159. In the saline soils in the lower parts of the basin (farm types 10 and 11), improved field drainage also has considerable economic potential with rates of return of almost 25% indicated where there are no problems with the main collector system. However, where there are these problems, the costs of cleaning out the main collectors may substantially reduce the rate of return. Improvements to farm drainage appear less attractive. The relatively poor performance of the latter can be explained by the high capital cost involved.

160. In the moderately saline areas typified by farm type 9, improvements to traditional irrigation practices are shown to offer the greatest return, followed by improved farm drainage and then land levelling.

161. Overall the results of the economic analysis indicates that there are substantial economic benefits to be gained from investing in water savings and productivity improvement in irrigated agriculture. Taking the most economic options for each soil type and aggregating the results to the total irrigated area for each type indicates that the economic benefits the CARs would gain from investments in irrigation would exceed

US$ 1 billion per year. This indicates the governments have a very strong economic justification for supporting investment in the irrigation sector.

162. In Regional Report 2 (section 7.2) it was estimated that under the currently prevailing conditions in irrigated agriculture, the economic losses as a result of shallow watertables and soil salinity amount to $US 1,750 million annually over the whole Aral Sea basin. This represents about 32% of the economic value of potential crop production.

163. The package of measures considered for rational water use and productivity improvement shows that if fully implemented over time an annual benefit in the order of $ 1 billion can be expected. This would ultimately bring the production value to about 85% of the potential value.

164. From the detailed analysis of the various improvements to irrigation it can be aggregated that under ideal conditions and over time, potentially a maximum volume of some 18 km^3 could be saved annually. However, savings achieved would for its greatest part be used for growing higher value crops that use more water.

165. This is demonstrated in the scenarios which were evaluated with the optimisation model ASBOM, where the results show that in 25 years time total water intake would be to 10% less than the current diversions of almost 100 km^3 annually.

166. Only in case policies and strategies would be agreed upon and implemented by the governments to allocate more water to the wetlands of the rivers and to the Northern and Western Aral Sea, the potential maximum water savings would be needed, which would have a direct negative impact on the agricultural production value as demonstrated in a scenario in which the required volumes for the wetlands and the sea were included as a priority. That test showed that some 24 km^3 of water annually would not be available for diversion to irrigation areas resulting in an economic loss of about $US 460 million annually.

4.3.4 Main and Interfarm Canal Measures

167. 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. The analysis was undertaken for 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.

168. 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 16, together with the results of sensitivity testing of higher cost levels.

Table 16: 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

169. 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. The results indicate that the rehabilitation of main and inter-farm canals is close to the most profitable of on-farm measures.

4.3.5 Non-viability of New Lands Development

170. According to data provided by the NWGs, the costs of constructing irrigation and drainage infrastructure in new land developments vary between $1,400/ha when the channels are largely unlined up to $4,500/ha when channels are fully lined. 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.

171. 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%.

172. The results showed that:

- Where the costs of new lands development include all costs of main 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 (IRR=10%-14%). Where the development does not involve lined canals or canalettes, cotton and vegetables on high or average fertility lands would be economic (IRR=14%-23%). Cotton-wheat specialisation on new lands would not be economic under any conditions.

173. 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 fertile areas have already been developed.
- Large-scale vegetable-growing is not a viable option, as vegetable requirements are met 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.

174. Although the above conclusions throw doubt upon the economic viability of large expansions of irrigated agriculture, 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.

4.3.6 Conclusion

175. The results of the studies clearly demonstrate that a number of packages of measures aiming at reducing water losses and secondary salinity and at the same time increasing crop productivity in existing irrigation systems are economically viable and should receive top priority by the governments for implementation.

176. On the contrary, development of new land for irrigated agriculture appears not to be economically viable (with a few exceptions).

4.4 Water Resources Balance And Water Sharing Principles

4.4.1 Current Water-sharing Arrangements

177. 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.

178. 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.

179. 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 Anticipated for 1995 (‘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

180. In the table the allocated diversion volume (km^3/year) is given from the river, and maximum irrigated area for 1995 is given on cotton - lucerne crop rotation. In opinion of Uzbekistan, under current conditions due to extension of less water consuming cereal crops, the irrigated areas could be increased.

181. The flow in the Amu Darya which passes to the Atamurat (Kerki) gauging station is shared 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.

182. 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 Anticipated for 1995 ('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

183. The allocated diversion volume is a volume of available water resources, and maximum irrigated area for 1995 is given on cotton – lucerne and rice crop rotation. In opinion of Uzbekistan, under current conditions due to extension of less water consuming cereal crops, the irrigated areas could be increased.

4.4.2 Current and Future Water Demands

184. From the analysis of current water use in irrigated agriculture carried out by the project and from scenario analyses of possible future water use made in computer models (Appendix 5) we conclude the following for the two basins:

Amu Darya						
Irrigable and irrigated area ('000)						
Country	**Irrigable area**	**1999**	**Future irrigated area 2025**			
			Scenario 2	**Scenario 3**		
				Optimum	**Self Sufficiency**	**Ecological**
Tadjikistan	479	475	456	443	709	448
Kyrgyzstan	0	0.0	0.0	0	0	0
Turkmenistan	1,714	1,713	1,572	1,619	1,643	1,575
Uzbekistan	2,380	2,089	1,753	1,954	2,380	1,651
Total	4,574	4,278	3,781	4,016	4,502	3,673
Water intake km^3/year						
Tadjikistan		5.4	4.9	4.5	7.0	5.6
Kyrgyzstan		0.0	0.0	0.0	0.0	0.0
Turkmenistan		19.2	18.9	18.0	29.8	22.5
Uzbekistan		32.6	30.0	29.7	17.8	16.7
Total		58.2	53.8	52.2	54.6	44.8
Syr Darya						
Irrigable and irrigated area ('000)						
Kazakhstan	784	770	637	659	784	579
Kyrgyzstan	400	397	400	400	400	366
Tadjikistan	259	256	158	158	242	158
Uzbekistan	1,892	1,744	1,593	1,616	1,892	1,329
Total	3,334	3,167	2,787	2,833	3,317	2,431
Water intake km^3/year						
Kazakhstan		12.78	11.9	11.7	9.5	9.1
Kyrgyzstan		5.02	4.6	4.5	3.6	3.9
Tadjikistan		3.26	2.1	1.9	2.5	1.8
Uzbekistan		19.75	21.6	20.4	19.5	15.1
Total		40.82	40.3	38.5	35.2	29.9
Total for the Aral Sea Basin						
Irrigable and irrigated area ('000)						
	7,908.2	7,445.7	6,568.1	6,848.8	7,819.1	6,104.5
Water intake km^3/year						
		99.0	94.1	90.7	89.8	74.7

185. At the same time, it is necessary to note that the basin states intend to develop irrigation involving new areas. According to the national programs, development of irrigation in the basin states would be as follows:

- Kazakhstan: It is expected to increase irrigated areas from 784 thousand ha in 2000 to 815 thousand ha by 2025. Water diversion volume will practically remain at the current level substituting areas which are now under rice crops for other less water consuming crops;
- Kyrgyzstan: Irrigated areas will be increased from 415.2 thousand ha in 2000 to 440.0 thousand ha by 2010, and 492.0 thousand ha by 2025. Water diversion for irrigation will be 4,275 mln. m^3 in 2000, 4,840 mln. m^3 in 2010 and 6,140 mln. m^3 in 2025;
- Tajikistan: According to "Concept on Rational Use and Protection of Water Resources in the Republic of Tajikistan" adopted by the Government on December 1, 2001, #551, the aim is to achieve its self-sufficiency in food by increasing productivity of existing lands (mainly irrigated) and by development of new irrigated areas up to 1.6 mln. ha. It is expected to increase the irrigated area from 718.3 thousand ha in 2000 to 1,188 thousand ha by 2010 and 1,578 thousand ha after 2025. Total water intake for irrigation will be 18,100 mln. m^3;
- Turkmenistan: According to the National Program "Strategy for Social and Economic Reforms in Turkmenistan for Period up to 2010", Turkmenistan intends to increase irrigated area from 1,860 thousand ha in 2000 to 2,167 thousand ha by 2010. Water intake will grow from 19,116 mln. m^3 to 23,833 mln. m^3. According to National Working Group, in Development Scenario 3, the irrigated area will be increased up to 2,638 thousand ha and water intake will be 26,089 mln. m^3;
- Uzbekistan: Water resources limits use in the Republic of Uzbekistan for middle- and long-term perspective in coordination with the strategic objectives for agricultural development of Uzbekistan and mainly for irrigated agriculture, will lead to increase of irrigated area. During the forthcoming decade (2001-2010) it is expected to increase irrigated area from 4,259 thousand ha in 2000 to 4,355 thousand ha by the end of 2010. For the long-term perspective, the aim is to increase irrigated area up to 6,440 thousand ha. However, taking into account financial, material-technical and other constraining factors, it is expected to increase the irrigated area up to 4,925 thousand ha by 2025. Currently, in Uzbekistan about 42 km^3 of transboundary water flow and 11.5 km^3 of national flow are used. In perspective, it is expected to increase total volume of surface water resources in the country up to 58.60 km^3.

186. The water balances for the current situation and for a number of scenarios are presented in Appendix 1. They are based on the average hydrological conditions of the period 1960-2000 and the current water demands, or the projected demands according to the development scenarios analysed.

187. Under the current conditions each country remains within the limits of water diversion as specified in the 'corrected complex schemes'. Also in terms of the irrigable area the countries have remained close to the areas foreseen in the former Soviet plans.

188. The highest priority in water resources management in Central Asia lies in the field of rational water use, the justification for that is presented in Section 4.3. Rational water use, through its various measures, can bring about enormous increases in the productivity of water used in irrigation.

189. It has also been demonstrated that development of new irrigation systems is, with a few exceptions, not economically viable. Besides that such new systems would draw heavily on scarce financial resources, it would also put an extra burden on the limited available water resources and at the same time would defavour and decourage the implementation of rational water use measures. However, the basin states are seeking for possible attraction of foreign investors and national budget funds to construct the new systems. For instance, in Kyrgyzstan not only the existing irrigated area is being rehabilitated, but the new irrigated lands are being developed as well. Consequently, water consumption increases. According to Kyrgyz information, crop productivity growth has been achieved.

190. In a scenario which focuses on obtaining self-sufficiency in grains, Tadjikistan would not be able to achieve that with the existing irrigated areas and especially in the Amu Darya basin more land would have to be taken into production. An additional test has been done with the optimisation model to determine the additional area required as well as the extra volume of water to be diverted. The conclusions is that 330 thousand ha would be needed to achieve self-sufficiency in grains also in Tadjikistan with overall an additional annual diversion of 2 km^3 of water. The total annual intake in Tadjikistan in the Amu Darya basin of 10.6 km^3, would still remain within the existing allocation. However, the consequence would be that less water would be available downstream, this would not impact on the self-sufficiency goals pursued in that scenario for the other countries but simply would result in a decreased flow to the Aral Sea.

191. We also note that there is considerable uncertainty about the growth of the population in future; the projections of the countries provided by the NWGs, which have been used in the project, add up to 70 mln people in 2025 in the Aral Sea basin parts of the countries, while the UN Population Division’s projections arrive at 55 mln people.

4.4.3 Interstate Water Sharing Principles

192. 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.

193. The three downstream countries have expressed the view that the currently prevailing water allocations for each country are of crucial importance to them and have to be maintained. For instance, Kazakhstan considers that it is very important to strictly follow water allocation principles according to Resolution #11 of State Expert Commission of State Planning Committee of USSR dated 05.05.1982, as violation of these principles will destabilize social and economic situation and deepen the ecological disaster in the Aral Sea area. Uzbekistan considers that the existing water limits of the Republic of Uzbekistan in the Syr Darya and Amu Darya basins are not to be disputed

and interpreted in different way. Uzbekistan considers that current annual water sharing principles used by ICWC correspond to the international law and cannot be mixed with the existing water limits in each country agreed by CA states.

194. The situation is different for the upstream countries. In the draft national water management plans, especially Tadjikistan proposes to expand the irrigated areas considerably with subsequent higher diversions of water. In Kyrgyzstan the focus for the Naryn sub-basin is more on the optimal use of the cascade of reservoirs for power generation in winter while Tadjikistan is expressing that they want to move in the that direction as well. Over the past decade, this has already led to a remarkable change in seasonal flows, affecting the downstream countries.

195. Although the upstream countries may argue in favour of allocating more water to them, we believe that with the limited economic capacities, new irrigation development will probably come about slowly. Moreover, with priority for rational water use and productivity increase in existing systems, also there is no pressing for additional land development.

196. 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. 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 in the future it would be reasonable to reconsider the water allocation limits. They are:

- The prevailing 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 in all cases agreed upon by some of the republics at that time, but were, or had to be, respected.
- In the past, irrigated agriculture was to be 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 operating regime of the Naryn has changed. In principle the current seasonal 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 Afghanistan 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.

4.4.4 Recommendations

197. Although there is no urgent need, nor a common ground yet to formally define new water sharing agreements, it is important for the countries to continue the dialogue on the issues of mutual interest in the water sector. During the next five to ten years the most important areas to pursue are:

- Implementation of policies, strategies and programmes and projects which give sole priority to rationalising water use and to increasing water productivity (see Section 4.3).
- Continuation of the process of liberalising agricultural policies in the countries, which is expected to lead to greater incentives for water users.
- Improvement of joint basin management through i) an improved framework agreement for the Naryn Syr Darya Cascade of reservoirs (see Section 4.5), and ii) pursuing a framework agreement for the Vakhs cascade of reservoirs.
- Seeking consensus between the States on mutual agreement to give the IFAS a higher profile and authority, as an international body, e.g. as a UN Special Commission. This would enhance its legal status and provide a platform for improved cooperation and coordination, and for funding of programmes and projects aiming at sustainable resource management in the Aral Sea basin.
- Codification of transboundary waters and the facilities on transboundary waters (See Section 4.6).
- Improvement of data collection, data base development and the exchange of data. This relates to hydrology, the agricultural sector, the energy sector and macroeconomics in general, including population growth projections.

198. It is recommended that an evaluation on progress made in the above fields will be undertaken somewhere around 2008-2010. That assessment should focus on what has been achieved and what directions are being pursued. It should also assess whether updated databases and projections have become available and whether these indicate trends that would make a revision of water sharing arrangements between the countries desirable.

199. In the meantime, it is recommended that the ASBP-2, currently being prepared considers the directions outlined above and integrates them in that program for the coming years.

200. It follows that for the coming five to ten years the existing water allocation arrangement will continue to be the temporary guideline till the necessity of the development of new arrangements can be justified.

4.5 Optimum Use of the Naryn-Syr Darya Cascade Potential

4.5.1 Management of the Naryn-Syr Darya

Toktogul Reservoir

201. Toktogul reservoir is the backbone of the regulation of the waters of the Naryn-Syr Darya basin. Together with the downstream reservoirs Kayrakkum and Chardara as well as with the Andijan and Charvak reservoirs on Karadarya and Chirchik rivers respectively, the system was designed with the principal aim of providing security in water supply for irrigation and to generate power. In the past Toktogul hardly changed the natural regime of the Naryn river flow. The live storage capacity of the reservoir of 14 km^3 is larger than the average annual inflow of 11.5 km^3, and provides the reserve needed for the water releases of the past even over a number of consecutive dry years.

202. However, when the water releases in a year are repeatedly higher that the average annual inflow, the storage becomes depleted and the multi-year storage and operation concept is broken and may take many years to recover. This situation almost appeared in 2002.

203. The table below summarizes how Toktogul was operated in the past and at present.

Table 17: Past Operation of Toktogul Reservoir

	Inflow	Losses	Release		Total	Average annual storage balance
			Non-vegetation season	Vegeta-tion season		
	km^3	km^3	km^3	km^3	km^3	km^3
Design (early 1970s)	11.83	0.3	2.8	8.5	11.3	0.2
Annual average: 1975-91 (16 years)	11.3	0.3	2.7	8.1	10.8	+0.2
Annual average: 1991-2001 (10 years)	13.0	0.3	7.2	6.1	13.3	-0.6
2000/01	12.8	0.3	8.4	5.9	14.3	-1.8

Source: BVO Syr Darya

204. Since 1992 some 27 km^3 (on average 3 km^3 per year) of water had to be diverted in winter to the Arnasay depression because of the limited flow capacity downstream of Chardara. As a result, the water has been lost as a resource and damage has been caused to infrastructure and land has been inundated.

205. Over the last seven years the countries negotiated agreements for summer releases that have come a long way towards mutually respecting the upstream and downstream interests. For four years the aim was to set the summer releases at 6.5 km^3. The average release was 6.2 km^3 during the first three years, but in 1998, due to the fact that it was a wet year, only 3.7 km^3 was realised. Since then the annual agreement has been to release 6 km^3 in summer, and this has almost been achieved, with average releases being 5.82 km^3. The real problem, therefore, is the excessive releases in winter.

206. Operation of Toktogul with 8-8.5 km^3 releases in the non-growing season, and 6 km^3 release in the growing season is not sustainable. This would lead to collapse of its multi-year regulating capacity; failure to produce the expected power generation; loss of some 2-3 km^3 of water per year to Arnasay; and increased tension and potential conflict.

4.5.2 Potential options for use of the NSDC

207. The following options deserve to be investigated to achieve the most rational and effective use of the NSDC:

- Provision of multi-year flow regulation operational mode of Toktogul reservoir (projected mode)
- Improvement of the framework agreement of 1998.
- Additional storage capacity
- Modified reservoir regulation at Kayrakkum and Chardara
- Increasing the Full Supply Level of Kayrakkum
- Diversion of water from the Chirchik and Akhangaran rivers to the Dostik canal.
- Construction of small reservoirs on tributaries in the Ferghana valley.
- Use of water spilled to the Arnassay depression.
- Construction of Koksaray reservoir.
- Increased use of groundwater.
- Changes in cropping patterns and rational water use in irrigation.

208. The most optimal and effective option for use of NSDC is to provide a multi-year flow regulation operational mode of Toktogul reservoir with exact fulfilment of obligations by the parties on compensation schedules. However, as the new independent states of the basin could not provide the indicated operational mode, and it is unlikely to provide it in the near future, the other options for NSDC use are considered below.

Improvement of the framework agreement of 1998

209. Various options on the improvement of the management of the NSDC have been considered in RR2 and in JR2. The most important are: i) to establish for a period of five years, or even better for 10-12 years, a sustainable release pattern for Toktogul which does not exceed the annual average long term inflow, ii) to also agree on winter releases, and iii) to adhere (guarantee) timely to agreed compensation schedules. The options considered for the improvement of the management are presented in Appendix 2.

Additional storage capacity

210. Consideration has been given to the creation of additional storage to help reduce the pressure on the operation of the Naryn Syr Darya cascade. Many potential dam sites are available upstream of Toktogul dam. Construction work started in the late 80's on Kambarata I (Naryn) but stopped after independence, it would offer a net storage capacity of 3.43 km3. A feasibility study on the Kambarata dams is currently undertaken by the NRMP project with support of USAID. Kyrgyzstan intends to complete Kambarata I, but not in the short to medium term. The main reason is the $US 1.2 bln investment required for which, given the economic conditions, financing can most probably not be attracted for years to come.

211. Another option is to create the Ala Bugin reservoir further upstream on the Naryn, with a potential storage capacity of 9.5 km3. The Kambarata I and/or Ala Bugin reservoirs would give a much needed increase in electricity generation and in conjunction with Toktogul can considerably solve the management problems of the NSDC.

212. No substantial additional storage can be created on the main stem in the middle reaches of the Naryn Syr Darya. Tributary flow of the Karadarya and Chirchik rivers is seasonally regulated by Andijan and Charvak reservoirs respectively, and all other tributary flow is seasonally regulated by the Kayrakkum and Chardara reservoirs.

Construction of small reservoirs on tributaries in the Ferghana Valle.

213. Feasibility studies are under way to investigate additional storage options in the Ferghana Valley. Apart from inflow from the tributaries, Kenkylsay reservoir (660 Mm3) would be supplied with water from the Big Namangan Canal and Rezaksay reservoir (190 Mm3) also by the BNC and, by pumping, from the North Fergana Canal. Hence, these reservoirs are designed to store part of the (higher) winter release from Toktogul for use in summer.

Use of water spilled to the Arnassay depression

214. In Uzbekistan construction is underway of two dikes and a pumping station at eastern side of the Arnassay depression, with the aim to use the water spilled from Chardara entering the depression in winter due to the higher releases from Toktogul, for irrigation in the Syr Darya system (Hunger Steppe). The volume involved would be about 0.5 km^3 per year. Besides, Uzbekistan considers that it is also necessary to take into account the water demands of Arnasay lakes system as a new natural system, which has the ecological and economic importance for middle-part of the territory of the Republic of Uzbekistan.

Diversion of water from the Chirchik and Akhangaran rivers to the Dostik canal

215. With the actual wateruse in the Chirchik basin, the available resources are not fully used, while reportedly some shortages occur in the Hunger Steppe. Therefore, Uzbekistan developed a plan to divert water from the Chirchik and Akhangaran rivers to the Dostik Canal. The plan involves the construction of the Pskem reservoir upstream of Charvak reservoir and the reconstruction of the Tuyubuguz reservoir on the Akhangaran river. Annual volume to be transferred would amount to 1.23 km^3 while in dry years would be only 50 % of that. The The Pskem dam would mainly serve hydropower interests but reportedly its costs are too high.

216. Implementation of the scheme would require agreement with Kazakhstan, since it would have a negative impact on the summer flow to Chardara reservoir and higher winter releases from Toktogul do not compensate for that.

Modified reservoir regulation at Kayrakkum and Chardara

217. Creation of a higher degree of regulation of tributary water only makes sense if it is to compensate for the changed operating regime of Toktogul. Even with a mutually agreed and sustainable operating mode of Toktogul involving, for example, 5.5 km^3 of winter releases and 6 km^3 of summer releases, some 2 to 3 km^3 would be released at the wrong time for the downstream countries. Modified operation rules for Kayrakkum and

Chardara could overcome this to some extent. This has been tested in the simulation model for the Syr Darya. According to Tadjik specialists, Kayrakum regulates only 5.2 km^3 out of total 6.0-6.2 km^3 of flow needed during the vegetation period.

218. Under WEMP A1, the BVO Syr Darya investigated this further and determined optimal releases from the five main reservoirs for various operation modes, which has been taken into account in the simulation work undertaken by the Consultant.

Increasing the Full Supply Level of Kayrakkum

219. At present the maximum operating level of the Kayrakkum reservoir is 347.5 m due to poor conditions of a number of dikes part of the flood storage capacity cannot be used, Uzbekistan and Tadjikistan are jointly investigating the reconstruction of the dikes, in order to bring the maximum operating level to 348.3 m which gives an additional 0.5 km^3 storage capacity.

Construction of Koksaray reservoir

220. Downstream of Chardara, Kazakhstan investigated the use of depressions at Koksaray for storage of excess winter flow that can be used for irrigation and for maintenance of an environmental flow. That reservoir would only be useful to store part of Toktogul releases in winter if the releases were to continue in the same pattern as they have over the past years. It would not be needed if the Naryn Syr Darya Cascade were to be operated in a sustainable fashion, and would introduce another loss to evaporation of about 0.4 km^3. In 2002 Kazakhstan decided not to pursue the Koksaray reservoir any further at this point in time.

Increased use of groundwater

221. There is scope for substantially increasing the use of groundwater for irrigation, especially in the Fergana Valley. This would reduce the need for summer releases from Toktogul and would lead to increases of the winter releases, which already at present cannot be sufficiently re-regulated downstream.

Changes in cropping patterns and rational water use in irrigation

222. Over the past decade, the cropping patterns have changed already significantly, the area for cotton decreased while the area for winter wheat and other crops increased. This allowed the downstream countries to agree on lower summer releases from Toktogul (see para. 5).

223. Water saving measures on-farm and off-farm do not automatically reduce the overall water use in the basin because water will be used in areas which at present are not fully used, or will be used by higher value crops that use more water, and for environmental purposes. On the other hand severely saline areas might be abandoned, or land is taken out of production for socio-economic reasons.

4.5.3 Conclusions

224. Of the ten potential options considered above, the following can be considered as rational and effective in improving the use of the NSDC:

In the short term:

- Improvement of the Framework agreement of 1998

- Increasing the Full Supply Level of Kayrakkum
- Construction of Rezaksay and Kenkylsay reservoirs
- Use of water spilled to the Arnassay depression
- Changes in cropping patterns and rational use of water in irrigated agriculture.

225. When implemented in combination, these measures give ample opportunities to reduce the current pressure on the management of the cascade, but do not solve the structural energy deficits in Kyrgyzstan completely.

In the medium to long term:

- Construction of Kambarata I and/or Ala Buka reservoirs

226. The following options are considered not to provide rational and effective improvements if the foreseen measures are not agreed by the basin states:

- Construction of Koksaray reservoir.
- Diversion of water from Chirchik and Akhamgaran catchments to the Dostlik Canal.
- Increased use of groundwater.
- Modified reservoir regulation at Kayrakkum and Chardara.

4.6 Transboundary Waters and Facilities on Transboundary Waters

227. When considering the issues related to transboundary waters in the Aral Sea basin, the Heads of the State of the Central Asian countries, since independence successively in a number of statements followed a clear line in policy objectives for the Aral Sea Basin.

- Agreement of 16 March 1993, Kzylorda

Confirming our adherence to the international water law principles, respecting mutual interests of each of sovereign states-participants of the present Agreement in the issues concerned with use and protection of water resources in the Basin, based on the necessity of the Sea saving, the parties agreed in the following:…

- Nukus declaration of 20 September 1995

III. Joining the international Convention and Agreements

We declare about our full supporting the international agreements, particularly, … about protection of transboundary waters…

- Ashgabat declaration of 9 April 1999

… taking into account that using of water resources in the Aral Sea Basin should be implemented according to the interests of all states with following the good neighborly and mutual interests principles.

Underlining a significance of the efforts of the states-founders of the fund in strengthening the collaboration in the water resources management and environmental protection, rehabilitation of water ecological systems, prevention of transboundary waters pollution.

- Dushanbe declaration of 6 October 2002

…about necessity to establish a special UN commission and develop Conception for sustainable development of the Aral Sea Basin states…

Heads of States of CA repeatedly declared about their respect and adherence to international law principles and ask UN to assist in involving the international financial institutes and bilateral-donors for solving the Aral Sea problem.

228. At present only Kazakhstan has ratified in January 2001 the UN/ECE "Convention on the Protection and Use of Transboundary Watercourses and International Lakes", Helsinki, 1992 (UN/ECE Convention). Kazakhstan as a Syr Darya downstream country is interested in adoption of the International Convention on Transboundary Waters Protection and Use by all the basin countries. Kazakhstan considers that joint transboundary watercourses use and protection and maintenance of favourable ecological situation should be based on the international norms. In Kazakh opinion, it will allow to develop a joint approach in solving the interstate water-related issues including transboundary waters and facilities.

229. Whether states ratify international Conventions or not is entirely to the discretion of each sovereign nation. Analysis of the national water laws of the Aral Sea Basin states shows that these laws, as a whole, do not contradict the UN/ECE Convention.

230. Acknowledgement of international law principles will enhance the basin countries case in requesting the UN to assist in securing the continued involvement of international financing institutions and bilateral-donors in solving the regional water and ecological problems for the purpose of sustainable development of the region.

231. Earlier the Consultant proposed that the Aral Sea Basin States adopt *the definition* of transboundary waters provided by the UN/ECE. 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'*.

232. This proposal was considered at the ICWC meeting in Almaty, 14-15 June 2002, and in the Protocol decision it was recorded: "For the ICWC members to consider the issue on introducing proposals to the Governments of their countries in the established order about the possibility to ratify the "Convention on the Protection and Use of Transboundary Watercourses and International Lakes, Helsinki, 1992", which is in line with the declarations of the Heads of State.

233. A draft list of waters in` the Aral Sea Basin that according to the definition in the UN/ECE Convention, can be considered to be transboundary waters was presented

in Phase V and has been reviewed during Phase VI and an update is provided in Appendix 3.

234. The list of transboundary waters and “facilities” on transboundary waters specified in the present information will be subject for discussion and one of the key directions for future work, as they touch the interests of all basin states and are necessary for the joint water management in the basin and improvement of the regional water management authorities.

235. The UN/ECE Convention does not define what is to be considered as ‘facilities’ on or at transboundary waters. In its articles, the Convention does not treat the subject of ‘facilities‘ or ‘structures’. Consultation with legal experts on international water resources law seems to indicate that there is no ‘international law’ that deals with existing facilities on transboundary waters. For planned facilities though, the UN 1997 Convention stipulates the need of prior notification in case a party plans to construct a new facility on transboundary waters.

236. In the absence of international law on the subject, each case would have to be part of negotiations between countries if prior agreement does not exist.

237. From the point of view of joint management of transboundary waters, it is important to define and to agree on the facilities and it is proposed that the States consider as facilities located on or at transboundary waters:

- dams and reservoirs;
- hydropower stations;
- weirs and other control structures;
- water diversion structures;
- interstate canals and canals of intrabasin water transfer;
- water outfall structures;
- surface and groundwater monitoring stations;
- groundwater abstraction and recharge facilities;

238. Appendix 3 provides the lists of facilities on the transboundary waters of the Amu Darya and Syr Darya basins, including the assessment of the current status of ownership, and operation and maintenance responsibilities.

239. The Consultant recommends that all facilities, which have substantial impact on the transboundary waters (surface and groundwater) in the two basins, will be considered as having the interstate status and are to be transferred into operational management of the BVOs with allotment of funds for maintenance (including the staff) of transferred facilities. The ownership of facilities would remain with the State. The form and extent of cooperation between the basin states on transboundary waters and facilities issues is an exclusive prerogative of the states themselves and depends on agreements between them.

240. This operational management transfer should be implemented on the basis of special interstate agreements only. Besides, it may not be possible in the short term since it requires stronger basin organisations, both in terms of their organisation and finances.

4.7 Mechanism For Joint Management of Water Resources In The Aral Sea Basin

4.7.1 Current Institutional Arrangements for Regional Water Management

241. 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.

242. 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.

243. 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 2. 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:

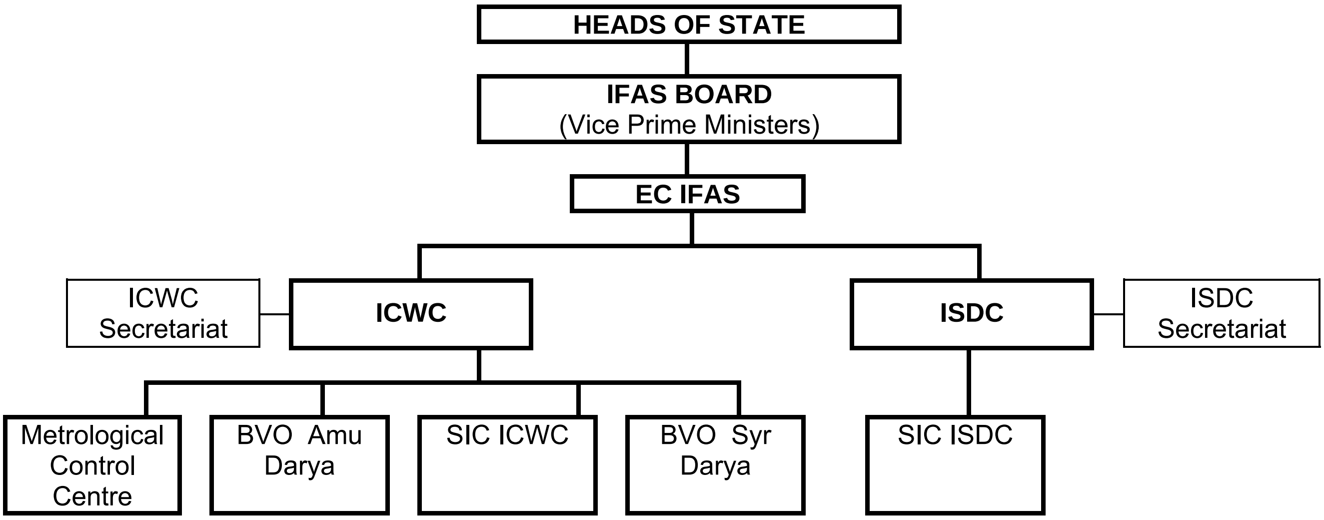
- water-related activities (ICWC),
- ecological, socio-economic and scientific-technical collaboration (CSD).

4.7.2 Current Deficiencies in Regional Water Management Institutions

244. The structure of the ICWC is illustrated in Figure 2. 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.

Figure 2: Existing Aral Sea Basin (IFAS) Institutional Arrangements



245. 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.

246. 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.

247. 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 not been established till date.

4.7.3 Institutional Strengthening

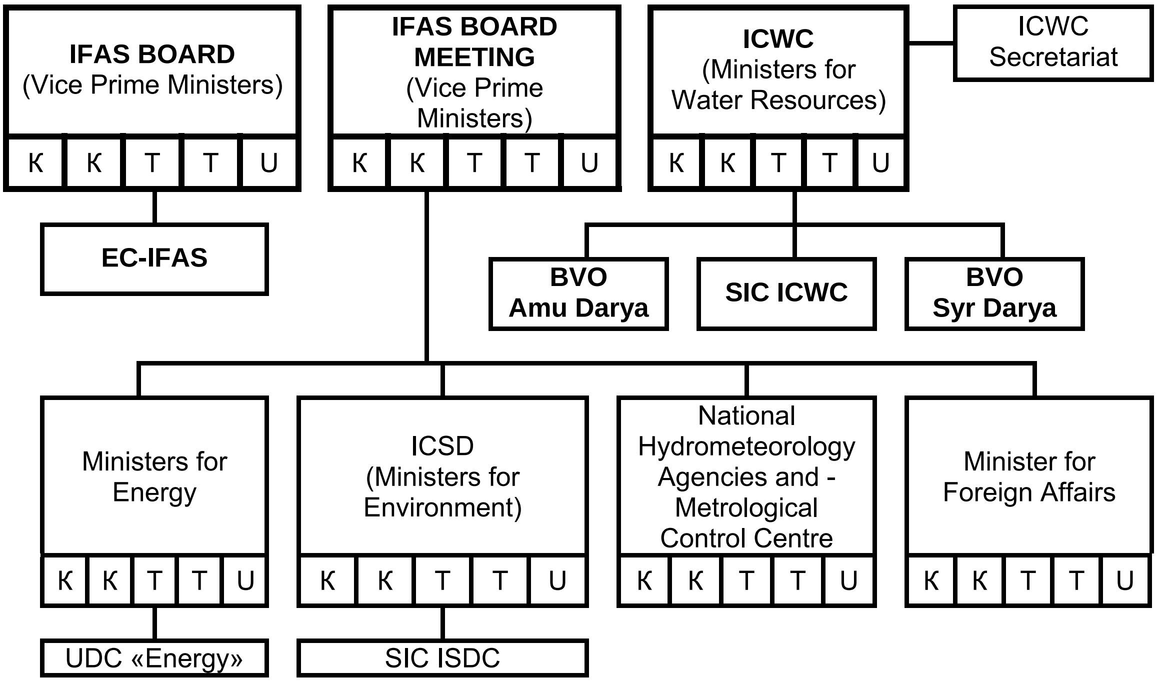
248. From the legal and organisational point of view the existing institutional relationship, developed under the framework of the Decision of the Heads of States about the status of the IFAS and its organisations (Ashgabat, April 8-9, 1999) have sufficient potential to satisfy institutional needs in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

249. 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. It is necessary to note that there are different points of view on reforming and strengthening the capacity of interstate institutions. For instance, Turkmenistan considers that it is unreasonable to change the existing ICWC structure, but it is necessary to strengthen its capacity by improving its technical and material resources and extending its power in operational fulfilment of tasks set by ICWC. Uzbekistan has the similar opinion on strengthening ICWC power and improvement of material and technical resources of BVO. 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.

250. 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.

251. 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 3.

Figure 3: Proposed Short-Term Aral Sea Basin Institutional Arrangements



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

253. 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 waters and also water quality management. It is obvious that certain changes in SIC-ICWC functional duties will take place, especially in the field of interaction with SIC-ISDC and UDC "Energy".

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

255. An outline for an alternative long-term perspective for institutional arrangements is described in Appendix 4.

4.8 Strengthening of the Water Facilities of Regional Importance and of the National Meliorative Systems

4.8.1 Strengthening of Water Facilities of Regional Importance

Dams and Reservoirs

256. The water facilities of regional importance are considered to be those structures which have an influence on transboundary waters of interstate use, such as:

- dams with storage reservoirs (with hydropower stations)

- diversion structures serving interstate canals
- water quantity and quality monitoring stations.

257. The existing dams which can be classified as water facilities of regional importance are:

Amu Darya basin:

- Nurek
- Tuyamuyun

Syr Darya basin:

- Toktogul
- Andijan
- Kayrakkum
- Charvak
- Chardara

258. Tadjikistan considers that the national water facilities of regional importance are to be managed by the national organizations until the necessary intergovernmental agreements on this subject are adopted.

259. Strengthening of the functioning of the regulation of the Amu Darya relates foremost to the operation of Nurek reservoir in Tadjikistan. Its life storage capacity is relatively small compared to the annual inflow. Over the past ten years, in summer about 1.5 TWh could not be generated due to a lack of a market. Only part of the generated electricity was exchanged with Uzbekistan who returned that in winter when Tadjikistan has an energy shortage of 1.5 to 2 TWh. Recently it is observed that annual bilateral agreements on power exchange between Tadjikistan and Uzbekistan for the Syr Darya basin, are functioning to the satisfaction of the parties. Tajikistan is interested also in signing an agreement with the Republic of Uzbekistan for power exchange in the Amu Darya basin.

260. Both Uzbekistan and Tadjikistan would benefit from an increased trade of summer and winter energy, and as mentioned in Section 4.5, a framework agreement could be developed for the operation of the Vaksh Cascade of reservoirs. This could first be a bilateral agreement with the option for other countries to join at a later stage. A recently, October 2002, developed bilateral Power Trade Relations Agreement between Uzbekistan and Tadjikistan could serve the purpose; several issues which were included but left open for later resolution would have to be addressed. The ADB, EBRD, and NRMP (USAID) are currently assisting the countries in this process, in the framework of a power transmission rehabilitation project.

261. There are two options to strengthen the regulation of the waters of the Amu Darya basin i) completion of the Rogun dam in stages, and ii) diversion of the waters of the Piandj to the Vaksh basin. The projects would annually add up to 15.8 and 13.1 TWh respectively, depending on the development in stages.

262. Preliminary cost estimates range from $US 125 mln for the first stage of Rogun (1 km^3 storage and 600 MW) to $US 1.7 bln for complete development of 3,600 MW and 13.3 km^3 storage); an estimate for the Piandj-Vaksh tunnel comes to $US 350 mln

allowing an increase of the Vaksh Cascade generation with 13.1 TWh annually. Further studies are needed to confirm the feasibility of the schemes.

263. The strengthening or optimum use of the waters of the Naryn Syr Darya basin has been reported in Section 4.5. With respect to the infrastructure of regional importance the conclusions are that in the short term the NSDC framework agreement has to be improved and that the level of the Kayrakkum reservoir could be raised to add 0.4 km^3 storage capacity. Option to increase the Kayrakkum storage capacity is currently under consideration by Tajik specialists. In the medium to long term the $US 1.2 bln Kambarata 1 and/or Ala Buka reservoirs in Kyrgyzstan, could be realized, preferably in consortium with the downstream countries.

4.8.2 Interstate Diversions

264. An assessment of the regional infrastructure under control of the BVOs was undertaken by each of the two BVOs for the project. Resulting from this, the BVO Amu Darya estimates the cost of rehabilitation of its infrastructure at $US 3.5 million, with annual operation and maintenance requirements amounting to $US 4.2 million, of which 30-40% is for dredging. The BVO Syr Darya estimates the costs for rehabilitation of the Big Ferghana Canal at $US 21.6 million, for the Dostlick Canal at $US 40.3 million, and for other structures at $US 1.2 million. Annual operating and maintenance requirements are estimated at $US 1.4 million.

265. In addition, discussions with BVO officers and several field trips to inspect BVO assets have provided an indicative picture of asset condition. The preliminary conclusions are that:

- all key infrastructure assets are in working order;
- routine maintenance of electro-mechanical equipment and minor repairs to structures are undertaken on a regular basis;
- the functioning of some assets is compromised by factors such as the lack of spare parts for critical components and concerns about structural integrity under design loadings; and
- rehabilitation and replacement activities are not being undertaken, except in emergency situations, for example, to replace structures that have collapsed.

266. Overall, the impression of the RWG is that the BVOs are managing to sustain their operations under difficult conditions brought about by a lack of financial resources. However, without a substantial boost in funding there will be a continuing deterioration in the overall standard of the infrastructure under their control.

4.8.3 Water Quantity and Quality Monitoring

267. At present there are about 200 monitoring stations in the Amu Darya basin and in the Syr Darya basin. Out of 200 stations, 35 have been upgraded under Component D of the WEMP. The monitoring stations are the responsibility of the national Hydromet organization. With assistance from Switzerland it is being considered to set up a regional Hydromet organisation, possibly under the aegis of IFAS.

268. Flow forecasting remains still to be improved, since over the past years it appeared that there were major deviations between the forecasts and the actual flow. Programmes are continuously ongoing to improve the snow cover monitoring and the

flow forecasting techniques. The BVOs monitor the diversion of water from the rivers to the numerous water intake structures.

4.8.4 Funding of Studies and Projects

269. Maintenance, expansion and improvement of water quantity and quality monitoring stations belongs to the routine activities of the Hydromets and BVOs, and sufficient funds have to be available to them to keep the system in good shape. The introduction of modern equipment or techniques could partly be funded through international financing.

270. Funding of routine O&M of the regional infrastructure is the responsibility of the national governments. Major rehabilitation works on dams, and the installation of dam safety equipment as carried out for 10 dams under WEMP Component C, is often realized with international financing. In Tadjikistan, the capital repair of dams is financed by national funds and ADB credits.

271. The BVOs are totally dependent on national government budgets for the financing of their activities. Funding levels from the various national governments is determined annually, with no guarantee of multi-year funding on which to base strategic investment planning. Moreover, a significant proportion of the funding is controlled by the national water agencies that undertake maintenance activities on behalf of the BVOs.

272. The expectations of the BVO management are that funding will continue to be limited for the foreseeable future as governments prefer to direct available funds to national priorities and are generally unwilling to contribute to the maintenance of objects on the territories of other countries. Priority for financing should be given to the repair of primary structures such as cascade pumping stations, river diversion structures and major control structures.

273. Clearly, to operate effectively the BVOs need security of funding – they need an assurance that not only will they receive all their budgeted funds, but also that they will have the financial management flexibility to carry out urgent repairs and maintenance that is required during any year. It is noted that the BVO agreement signed in Almaty by representatives of the five States on 18 February 1992 states (Article 9) that “Basin water authorities are funded from subscriptions of water institutions of the republics on the conditions of parity and shared contribution”.

274. Funding of major new projects or completion of projects which were halted after Independence would still require the assistance from International Financing Institutions for project preparation, evaluation and implementation. Since the investments in complete implementation of these projects are enormous, staged development is often required. The economic reforms carried out in the basin states are different, and this may cause constraints for settlement of interstate water relations. Therefore, it would be reasonable for the states of the region to adopt the institutional development program for national water management authorities and infrastructure, as well as for strengthening of legal, administrative and economic fundamentals for water resources management and nature protection at the regional and national levels. Also, it is necessary to provide for the involvement of the population and NGOs in preparation and decision making process.

4.9 Strengthening of the National Meliorative Systems

4.9.1 Introduction

275. In Phase IV of the project, the NWGs developed National water and salt management plans following guidelines established by the RWG. These 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. The plans follow closely the relevant government development policies for the short to medium term. The national plans are generally based on high growth scenarios. The national plans have received preliminary endorsement from the relevant government agencies. The plans were presented in detail in the National Reports No. 1, and have been updated during Phase VI (National Report 2). The key aspects are summarised in the following sections. An overview of the plans is then presented, which provides an assessment by the Consultant of their practicability from a national and regional viewpoint.

4.9.2 Kazakhstan

276. 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 93-95% of the available water resources or 88-90% of the total water use. 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.

277. 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 57% to about 76% in 2010-2020 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 of land-reclamation and water management measures, i.e. increase of various canals' efficiency, repair and modernisation of drainage systems, improvement of water application techniques and technologies, leaching of salinised lands, as well from 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 2010-2020 by these measures.

278. Investment in irrigation is estimated at $US1.3 billion in the period 2001- 2010, and a further $US 30-95 mln/year up to 2025. The plan envisages increasing investment by the private sector in irrigation projects, with eventually about 15-25% coming from this source, 45-50% from state sources and the remainder in the form of international loans.

4.9.3 Kyrgyzstan

279. The population in the Kyrgyz segment of the Aral Sea Basin is currently about 2.2 million. It is projected 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 25,000 ha of irrigated land will be brought into production by the year 2010 and a further 52,000 ha by 2025.

280. 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.

281. Investments required for increasing of canals' efficiency, for repair and modernisation of drainage and improvement of water application techniques and technologies are estimated at about $US 300 million for infrastructure rehabilitation and new land development, and $US 8.7 million for O&M per year. 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.

282. As for hydrogeneration facilities, the Kyrgyz Government is seeking investors for the construction of Kambarata 1 and Kambarata 2 hydropower 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.

283. 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.

4.9.4 Tadjikistan

284. Tadjikistan has considerable water resources; 10 km^3 of the total 65.5 km^3 of river flow originating annually on average in its territory currently is 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. The national population is projected to grow to 8.5 million by 2010 and 10.0 million by 2025.

285. 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 1,188,000 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 13.1 km^3 to 15.4 km^3

by 2010 and to 20.35 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.

286. 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.

287. 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 1.5 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.

4.9.5 Turkmenistan

288. The surface water resources of Turkmenistan, comprising 22 km^3 per year 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.

289. To provide adequate food the plan envisages an increase in the irrigated area from the current 1.86 million ha to 2.17 million ha in 2010 and 2.64 million ha in 2025. The assumed cropping pattern in 2010 includes about 705,000 ha of wheat and 648,000 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, repair and modernisation of collector-drainage network, improvement of water application techniques and technologies, leaching of salinised lands at the on-farm level. The overall irrigation efficiency (including field efficiency) is assumed to increase from the current 58% to 67% by 2010.

290. 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

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

4.9.6 Uzbekistan

292. 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.

293. It is envisaged in the most optimistic scenario that the irrigated area will increase from the present 4,259,000 ha to 4,355,000 ha by 2010 and to 4,925,000 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.

294. The plan assumes that substantial improvements in various irrigation canals' efficiency, repair and modernisation of drainage network, water application techniques and technologies and leaching of salinised lands will be achieved through organisational and institutional measures, to provide the necessary water for the new developments. The assumed values for the overall efficiency are 39% at present, to increase to 69% by 2025. They represent reductions of 6% in the volume of irrigation water applied per hectare by 2010, and of 15% by 2025.

295. 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. 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.

296. 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.

297. 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.

298. The proposed investment in the period to 2025 amounts to a total of $US 15.5 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	12.8
Total	15.5

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

4.9.7 Overview of National Plans by the International Consultant

Water Productivity Improvements and Optimum Use of Existing Schemes

300. The plans all assume significant increases in irrigation efficiency in the future, through both technical measures (seepage prevention, improvement of water application techniques and technologies, leaching of salinised lands, introduction of water assessment and water measuring devices, repair and modernisation of collector-drainage network) 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.

301. 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.

302. A major conclusion of the RWG's studies is that priority should be given to making optimum use of existing irrigation schemes before consideration is given to the development of new irrigation projects. The justification for this priority is presented in Section 4.3.

Aral Sea and Delta Wetlands

303. 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 4.2, it would be desirable for ecological reasons to pass a total of about 26 km^3 annually of water to its delta wetlands and to the Aral Sea.

304. The volume currently passed through to the Sea and its wetlands amounts on average to about 12 km^3 annually. The national plans do not appear to allow for any significant increases in individual national allocations for environmental purposes. In fact, since the estimates of future water demands are high, there is at least for the short to medium term, likely to be pressure to decrease the ecological flows to enable social and economic objectives to be achieved.

305. Hence, when the national plans would eventually be implemented, it is unlikely that sufficient flows would be available, especially to restore the Western Aral Sea into an ecological sound water body.

Concentration on Physical and Financial Aspects

306. In general, all national plans address adequately the physical requirements of the water and energy infrastructure, and the necessary funding. Initial stages usually include repair and emergency work, and priorities are given to those structures, which operation deficiency impacts the whole or major part of irrigation and drainage systems. Reconstruction and modernisation are considered at the next stage. 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 more incentives for water users, 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.

307. 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.

Prioritisation of Measures and Development Works

308. 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, followed by assessment of social and environmental aspects. Economic analyses of various on-farm measures by the RWG are summarised in Section 4.3. The results are available to the NWG to assist in the prioritisation.

Funding Practicability

309. 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.

310. 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. 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.

Analysis of Draft National Plans in the Regional Context

311. The potential development scenarios presented by the NWGs in their 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.

312. 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

313. The RWG 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. 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. 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.

5. REGIONAL STRATEGY DEVELOPMENT

5.1 Basic Issues

314. 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. River water salinity is not a significant problem for irrigated agriculture over the short term, but results in additional costs over the long term in the delta areas such as Dashovuz and Karakalpakstan.

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 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. To solve the above indicated problems it is needed to develop special environmental programs for the entire Aral Sea basin starting from the upper reaches.
- 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 26 km^3 per year in the two rivers would be needed to maintain reasonable conditions in the delta wetlands and

lakes and the Northern Aral Sea, and restore in the very long term the salinity levels in the Western Aral Sea to a sustainable level for fish life.

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 they operate basically as monitoring organisations.

5.2 Draft Regional Policy

315. From a regional Aral Sea Basin perspective, the major policy directions for water management in the short to medium term are:

On water sharing between the States

- To recognize that for the coming five to ten years there is no urgent need, nor a common ground to define new water sharing agreements for the two river basins. The existing water allocations will continue to be the temporary guideline till the necessity of the development of new arrangements can be justified.

It is observed that Tadjikistan in particular could be entitled to a larger share, however, as is the case in the other countries, rational water use in existing irrigation schemes, and financial constraints may substantially defer a need for a larger share of the basins waters.

On the Aral Sea and delta wetland ecosystems

- To recognize that currently there is no firm allocation of water to the Aral Sea, and since it is not expected that major water allocation changes will come about soon, it follows that especially the Larger Aral Sea would continue to shrink. Saving the Northern Aral Sea as an ecologically sound water body, in fact stabilizing it at its current level, is feasible and an objective being pursued by Kazakhstan.
- There is no environmental, social or economic justification to promote the saving of the Larger Aral Sea. Even in the hypothetical case that a fixed allocation of water to that part of the Sea could be agreed and gradually be implemented, it would take some 40 to 50 years to restore only the western part of the Larger Aral Sea into an ecologically sound water body. If fully implemented, rational water use measures could save 5-10% of water currently diverted for irrigation. That would potentially double the flow to the Aral Sea, and provide the water required to save the western part in the long term.
- To give priority to the restoration and safeguarding of the ecosystems of the entire Aral Sea basin including delta wetlands through the implementation of

'flood plain management', which also brings about much needed social benefits in that region.

On agriculture and water management improvement

- To continue the gradual process of liberalising agricultural policies in the countries as to provide greater incentives for water users to increase production while using less water.
- To give priority in the countries on the implementation of rational water use measures in main and inter-farm supply systems, and on-farm, both show high economic returns and reduce water losses, and will eventually have a regional beneficial impact on sanitary flows throughout the whole river system and will contribute to the restoration of the wetlands in the deltas.
- To recognize that large scale new lands development for irrigation is not justified in terms of needs, and, in general, does not seem to be is economically not feasible.

On interstate cooperation

- To continue interstate cooperation in water management through existing organisations which will be strengthened by formal representation of other sectors.
- To seek consensus between the States on giving the IFAS a higher profile and authority, as an international body, e.g. as a UN Special Commission. This would enhance its legal status and provide a platform for improved cooperation and coordination, and for funding of programmes and projects aiming at sustainable resource management in the Aral Sea basin.
- To recognize that the way forward in strengthening commercial cooperation in the water and energy sector can be achieved through bilateral agreements rather than pursuing this through Aral Sea basin wide agreements.

5.3 Draft Strategy

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

317. 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 legal backing 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 them to obtain 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.

318. The greatest challenge, however, will be the introduction of the necessary measures to improve on-farm and off-farm water management. The problem of the loss of approximately half of the water diverted for irrigation is of great significance for all countries. Realistically, in view of the shortage of funding, this objective is unlikely to be achieved fully in less than 20 years. Prioritisation is the major tool to be used here, to ensure that the scarce funds are used first on the projects that will provide the greatest economic return and thus assist the essential rebuilding of the various national economies.

6. INSTRUMENTS FOR STRATEGY REALISATION

6.1 Incentive Framework

319. The most obvious incentive in water management is the introduction of realistic charges for water delivery services based on volumetric measurement of consumption. These provide the spur for increased efficiency. Service fees could be introduced at both a regional and local (on-farm) scale.

320. The regional delivery, the losses between the river offtakes and delivery to the farm boundary are the responsibility of the national and regional water resource authorities. The national water authorities could be charged a supply fee per unit volume by the river basin authorities (the Syr Darya and Amu Darya BVOs) to cover operating and maintenance costs. The concept here is to develop an incentive for the national authorities to minimise the losses between the river offtakes and the farm delivery points. However, before this could realistically be adopted the powers and responsibilities of the BVOs would have to be increased substantially.

321. Demand management has greater scope in regard to on-farm water use, because individuals are involved. In fact, demand management measures are already being implemented to an extent, with the introduction of some form of water charges. The privatisation of agriculture and the formation of Water User Associations, which is currently in process in most countries, will result in a much more direct perception of the link between water consumption and cost. Thus privatisation is a measure that will directly assist demand management, whether that is the primary objective or not. Ideally, farms should be charged on a volumetric basis for all water delivered to the farm boundary, and there should be emphasis on collection of these supply charges. However, in many instances, under the current system of state orders, the charges are not collected because the farmers cannot afford to pay them, thus negating any incentive for minimisation. Demand management will be relevant therefore only in situations in which agriculture is sufficiently profitable to allow payments for water delivery services that are not an unreasonable financial burden. In this regard, experience elsewhere (e.g. Bangladesh, Nepal) suggests that poor farmers are willing to pay for good quality irrigation services that raise and stabilise their incomes. In the long term, water charges should be set at realistic levels - that is, they should fully cover the costs of operating and maintaining the irrigation and drainage infrastructure.

6.2 Institutional Tools

322. The regional water organisations should be strengthened with equal, or certainly more balanced, representation from all the riparian States, and should be empowered to carry out the following functions:

- Preparation of long-term plans and operating procedures for the key transboundary river reservoirs and offtakes taking into account the need to provide for periods of drought and high flows;
- Preparation of annual management plans for the reservoirs, taking into account fluctuations in inflows and changes in the benefits and costs associated with alternative operating regimes;

- Control of the operation, maintenance and rehabilitation of all transboundary water management and hydropower generation structures;
- Resolution of disputes between the participating parties with regard to any operation, maintenance or rehabilitation issue;
- Coordination in emergency situations; and
- Facilitation of the establishment of compensation between the States for a chosen operating regime.

323. It is suggested that operation, maintenance and rehabilitation of all transboundary water management and hydropower operation structures should remain with the respective State agencies, but under the oversight of the BVOs. To that end the monitoring capacity needs to be enhanced.

6.3 Financial Possibilities

324. Since it is not possible any more to rely on governments for funding because of their budgetary problems, it is becoming more and more accepted to introduce, or where applicable strengthen, the instrument of water use charges to recover the real cost of operation and maintenance. However, the dilemma is that there is little opportunity for farmers to increase their incomes in the situation where they have no say in what, and how much, crops they grow. Consequently, they simply do not have the capacity to pay increased water charges.

325. The private sector will be very important in mobilising sufficient funds, particularly for efficient on-farm investment as well as to finance the maintenance of the main infrastructure facilities that are the responsibilities of the BVOs. However, cost recovery requires the provision of good quality irrigation services that raise and stabilise farmers' incomes. Providing farmers with reliable, profitable, and sustainable irrigation services, and incentives, is a critical issue.

326. With respect to domestic and industrial water supplies, volumetric water delivery and treatment charges that reflect the true costs of providing the service will also need to be introduced over the long term.

6.4 Priority Setting

327. The broad priority water resources management concerns to be addressed are:

- inefficient water use;
- land and water salinisation; and
- ecosystem degradation;

328. The priority institutional and financial problems are:

- the inadequacy of the water administration to address the central water, energy, agriculture, and environmental issues;
- the gap between policy/planning and implementation; and
- the inadequacy of financial resources.

329. 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 Governments relax controls to enable farmers to become more market-driven in deciding what crop(s), and how much, they grow, 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.

330. Further, it is considered that improved water management has the potential to reduce water losses by 18 km^3 per year. This volume could become available for ecological, sanitary or other purposes. The water made available for the Aral Sea should in the first place be used to restore the delta ecosystem to preserve their ecological value and use their potential for fish farming and animal husbandry for the local population.

7. ACTION PROGRAM

7.1 Objectives and Targets

7.1.1 Objectives

331. The concrete objectives to be achieved during the first 5 to 10 years include:

- seeking agreement by the five States on the minimum average flow requirements in lower reaches of the Amu Darya and Syr Darya rivers for sanitary and ecological purposes in general, and on the issue of the eventual saving of the Western part of the Aral Sea in particular.
- seeking agreement on the proposed codification of transboundary waters and of the facilities on them.
- strengthening of current institutional structures (IFAS, ICWC, BVOs) by effectively increasing their capacity.
- improving the agreement on a river regulation and electrical generation regime for the Naryn-Syr Darya system that is sustainable in the long term, and to seek a similar agreement for the Nurek system.
- Reduction of 50% in in-field seepage losses and about 40% in drainage flows.

7.1.2 Institutional reform targets

332. The concrete targets for institutional reform to be achieved during the first 5 to 10 years include:

- Higher level of decision making (Annual Joint Meeting headed by the Vice Prime Ministers),
- Representation of authorised representatives of the related sectors of economy (energy, ecology etc.),
- Rotation of key staff positions between countries,
- Open and regular information exchange,
- Transfer of main off-take structures to BVOs.

7.1.3 Operational improvement targets

333. The concrete targets for operational improvements to be achieved during the first 5 to 10 years include:

- Establishment of an operational mode for Toktogul reservoir that ensures that annual average outflows do not exceed average annual inflows in order to maintain the multi-year regulating capacity. For example, consideration should be given to agreed outflows of 5.5 km^3 in the non-vegetation season and 6 km^3 in the vegetation season, with inter-annual adjustments depending on actual inflow.
- Introduction of Demand Management i.e. increasing the efficiency of water use, including the control of irrigation canal flows, which with better

measuring and control equipment can be more accurately tailored to demands, with less water spilled to waste.

7.2 Policy, Institutional, Economic and Financial Actions

334. The principal policy action relates to the rational use of water in the region, i.e. increasing the efficiency of water use. Apart from measures mentioned in this report, specific action will include raising public awareness through the educational and other programs concerning the problems of nature protection, rational use of natural resources and improvement of environment for present and future generations. It is proposed also to use this mechanism to deliver the strategy and action program ‘on the ground’.

335. The principal institutional action relates to strengthening collaboration to solve issues on water management, environmental protection, restoration of water ecosystems and prevent transboundary water pollution. Apart from the institutional measures mentioned in this respect, specific action will include seeking agreement on a broad framework for basin-wide institutional arrangements (and sorting out water sharing arrangements and specific operational details and functions later).

336. The principal economic action relates to the necessity for governments to relax controls to enable farmers to become more market-driven in deciding what crops, and how much, they should grow. Specific action will include the abolition of the system of ‘state-orders’ and government control of commodity prices in the agricultural and energy sectors where these still exist.

337. The principal financial action relates to attracting funds for implementation of measures and actions. Specific action will include improving institutional and economic conditions so that they are conducive to private and public investments in the water sector.