Sharing the Aral Sea

Introduction

Kazakhstan, Uzbekistan, Turkmenistan, the Kyrgyz Republic and Tajikistan are sovereign nations that were once part of the Union of Soviet Socialist Republics. These nations are known as the Central Asian Republics and located within this region is the Aral Sea. Once the fourth largest inland lake in the world, the Aral Sea is an environmental disaster orchestrated by the Soviet Union. A common slogan during the Communist regime was "Everything for man, everything for the service of man" (Pryde 1995). The Aral Sea was no exception. Two rivers, the Amu Darya and the Syr Darya, flow into the sea, a closed water basin. During the 1960's, the government mandated that both rivers support the agricultural production of cotton. With the breakup of the Soviet Union in 1991, the Central Asian Republics became independent nations that used transboundary water resources for irrigated agriculture and hydropower generation. The water allocation scheme developed by the Soviet Union did not satisfy the sovereign republics' needs. Upstream republics envisioned using the water resource to increase hydropower production and expand agricultural activities. Downstream republics relied on a steady water flow to irrigate the agricultural production of cotton. The Central Asian Republics struggled to arrange a natural resource management plan of the Syr Darya basin that satisfied the needs of each country.

History of the Aral Sea Region

The irrigation program developed by the Soviet planners had severe environmental consequences for the Aral Sea region. The Soviet initiative resulted in "destroyed ecosystems, an end to commercial fishing, a dramatic decline in agricultural productivity brought on by increased soil salinity and localized climate change leading to a drastically shortened and much drier growing season, contaminated ground water and a severe public health crisis" (Delivery Order 12). Cultivation of cotton and inefficient water management used by state farms and collectives caused water diversion used for irrigation to contaminate, salizine the soil, and reduce the amount of water delivered to the Aral Sea (Spoor 1998). A local proverb, "In every drop of water there is a grain of gold," demonstrates the importance Soviet planners placed on water diverted from the Aral Sea to produce cotton (Grabish,1999). The exclusive focus on "white gold" (cotton) under a social organization of production that ignored environmental impacts of inadequate long-term resource management, turned into a 'tragic experiment' (Rumer 1989).

River water diverted for agricultural irrigation impacted the Aral Sea's water quality. In 1960, the Aral Sea had a volume of 1090 km^3 supplied by the natural surface flows of two rivers (Britton 1997). The Amu Darya and Syr Darya supplied the Aral Sea with approximately 45-55 km of water annually (Spoor 1998). As the cotton acreage in the Central Asian Republics expanded, larger volumes of Amu Darya and Syr Darya River water was diverted for irrigation. "By the early 1980's on average not more than 7 km reached the Aral Sea annually; in some years no water at all passed through the Amu and Syr Darya deltas" (Spoor 1998). Table 1 and Figure 1 depict degradation of the Aral Sea over a 40 years time span. The sea level declined by 12 meters with a 50% reduction in surface area resulting in salinity levels that have tripled (Figure 1). The Aral Sea splintered into two, a large southern and a small northern, seas by the late 1980s (Figure 1).

The Soviet System

Collapse of the Soviet Union in 1991, brought independence to the republics along with new natural resource management concerns. In 1992, the water ministers of the Central Asian

Republics agreed on a temporary stay of the 1982 water allocations developed by Soviet planners. The 1982 water allocation scheme was based on the assumptions that (Britton 1997):

1. The region was part of one country;
2. The region's waters and hydro dams were developed to serve agricultural irrigation;
3. Water deficits could be alleviated by an interbasin transfer from Siberian rivers; and
4. Upstream hydropower development could be facilitated through project development of the Kambarata Dam.
5. Upstream countries were provided wintertime heating fuel in exchange for wintertime water storage for spring and summer irrigation.

The Soviet scheme arranged water rights such that irrigation was the primary goal and a secondary result was hydropower generation for the Kyrgyz Republic. In 1994, the United States Agency for International Development's Environmental Policy and Technology Project provided assistance to develop a water management policy for the Central Asian Republics. The republics needed aninternational agreement to organize the water allocations for both the upstream and downstream republics.

Using the 1982 water allocation scheme did not meet the water and energy needs of both the upstream and downstream republics. Storage reservoirs were located in upstream countries, while downstream republics conducted irrigated agriculture. Table 2 demonstrates the need for an international agreement among the Central Asian Republics. The Soviet scheme resulted in republics not equally benefiting from the Syr Darya River. As sovereign nations' the Central Asian Republics struggled to develop democratic government systems and market economies that maximize benefits from natural resources. Contrary to Soviet planning, each republic independently planned water uses of the Syr Darya River that brought prosperity to their country. The downstream republics depend on continuous water supplies for crop production while the upstream republics search for ways to expand their hydropower generation and increase their own agricultural production acreage. Each scheme, irrigated agriculture and hydropower generation, support opposing management plans for the Syr Darya basin. The Central Asian Republics must design an international agreement that expresses the position of each republic while adequately sustaining the natural resource.

Position of Each Republic

The Syr Darya River originates in the Kyrgyz Republic, flows through the fertile Fergana Valley of Uzbekistan, dips into the most populous region of Tajikistan and then flows back through Kazakhstan's agricultural producing areas to the dry Aral Sea zone (Figure 2 and Figure 3). Formed in the mountains of the Kyrgyz Republic, a series of cascade reservoirs harness the Syr Darya River. Located in the Kyrgyz Republic, the largest reservoir, Toktogul, is the region's major water storage and hydroelectric facility. Other reservoirs scattered along the Syr Darya have limited power generation capacity and operate at constant volumes, thus unable to regulate the Syr Darya's flow rate. Toktogul reservoir originally operated to satisfy downstream agricultural practices. The birth of democracy caused the Central Asian Republics to assert competing uses for the Syr Darya Basin that included hydropower, irrigation, municipal use, industrial uses and identified the Aral Sea as a potential consumer. As a finite resource the republics struggled to develop a management plan that embraced the needs of all republics.

The policy goal was to promote sustainable water management of the Syr Darya Basin among the Central Asian Republics of Kazakhstan, Kyrgyzstan, and Uzbekistan (Table 5).

The Central Asian Republics' aimed to satisfy the needs of both upstream and downstream republics. Upstream republics were "searching for ways to expand economies through use of water for hydropower and expansion of the agricultural sector, while the downstream agricultural regions are dependent on continuous water supplies for crop production" (Britton 1997). As independent nations, each republic identified uses for the Syr Darya's water.

Uzbekistan

The government of Uzbekistan acknowledged the nation's extensive natural resource issues. Action to ameliorate and mitigate environmental problems consists of written and oral commitments. Though Article Four of the Constitution states "citizens are obligated to behave protectively toward the surrounding natural environment," the government fails to organize bureaucratic agencies to participate in environmental problems (DeBardeleben 1995). Article 5 of the law "On Water and Water Use" states, "water is a state property, national wealth of the Republic of Uzbekistan. It is to be rationally used and is protected by the state" (Kasymova 1999). A bureaucratic web of agencies with no formal organizational structure and scarce financial resources weakened the republic's environmental declaration. Addressing environmental problems in Uzbekistan is limited by lack of law enforcement in natural resource issues, inconsistent government economic and environmental planning, corruption and the concentration of power in a President who demonstrates little tolerance of natural resource management planning.

Uzbekistan, as a downstream republic, defines the Syr Darya River as a natural resource that supports irrigated agricultural activities. As listed below, the republic identified three issues for an international water management agreement: (Britton 1997)

- Maintain the operating regime in the irrigation mode.
- Favors status quo in terms of water allocation, timing of release, and administration of water resource management.
- Willing to compensate Kyrgyzstan for winter storage and summer release.

As an independent nation, Uzbekistan maintains strong affiliation to Communist ideals and management practices. A high economic priority is the production of cotton and rice through irrigated agriculture. Uzbekistan, a nation in transition, does not identify natural resource management as a national priority. The weak environmental regulatory system, support for the Communist water allocation scheme, and reliance on traditional agricultural practices demonstrates Uzbekistan's low level of concern for negotiating a new water management agreement.

Kyrgyz Republic

Environmental legislation and regulations of the Kyrgyz Republic convey strong nationalism spirit for natural resources within its borders. Article 5 of the Law "On Water" mandates that, "the state water fund of the Kyrgyz Republic is a property of the state" (Kasymova 1999). The Kyrgyz Republic's position on a water management agreement emphasizes the need for equity among the Central Asian Republics. Five issues listed below depict the Kyrgyz Republic's position: (Britton 1997)

- Development of its hydropower production capabilities as a major area of economic growth.
- Cannot continue to operate reservoirs without some form of compensation for wintertime heating fuel.
- Electricity prices should be near world prices. Central Asian electricity prices are currently below world prices.

- Promote development of two new upstream hydropower projects.
- Operating and maintenance costs of the reservoirs need to be equitably shared among the republics.

The Kyrgyz Republic absorbed the costs of operating and maintaining the reservoirs within its boundaries during the Soviet era. For access to the Syr Darya River, the Kyrgyz Republic mandates that an agreement should require downstream republics to compensate upstream republics. The reservoirs contained within the Kyrgyz Republic control the water flow rate of the Syr Darya River. Downstream republics rely on steady water flows for irrigated agriculture. To continue providing Uzbekistan and Kazakhstan with irrigation water, the downstream republics must compensate the Kyrgyz Republic for the lost of hydropower generation. Operation of the reservoirs in irrigation mode limits the Kyrgyz Republic's ability to generate electricity during the wintertime months. The Kyrgyz Republic's position adheres to the Soviet era by emphasizing that each republic can prosper thru cooperative use of a transboundary natural resource.

Kazakhstan

Among the Central Asian Republics, Kazakhstan achieved the most successful transition from Communism to Democracy. Government officials acknowledge the importance of natural resource management through legislative mandates and creation of bureaucratic agencies to administer environmental programs. Article 4 of the Water Code states "waters in the Republic of Kazakhstan are an exclusive property of the state" (Kasymova 1999). Concerning the Aral Sea Basin, the Kazakhstan government conducted official meetings and conferences (more than 300), but few programs were adopted or implemented.

Kazakhstan, a downstream republic, mandates that an international water management agreement should promote the transition to democracy. The republic identified four key issues for an agreement: (Britton 1997)

- Differential compensation for poorer water quality because the resource is either highly saline or have been intercepted and does not reach Kazakhstan at all.
- Agreement should use the 1992 Helsinki Convention on transboundary waters as a model.
- Unable to make scheduled coal delivers or to make purchases of summertime hydropower from the Kyrgyz Republic due to difficult economic situation and privatization of the energy sector.

The position held by Kazakhstan depicts a nation struggling to embrace world markets and democratic practices. Kazakhstan's transition is progressive compared to other Central Asian Republics. Soviet planners relied on each republic's dependence on one another to fuel national and regional goals. The republic of Kazakhstan aims to be self-sufficient and operate in accordance with standard world economic principles.

Valuation of Water

Among the Central Asian Republics' tension between upstream and downstream republics plagues the formation of an international agreement. Prior arrangements assessed water rights without considering the needs of independent nations. A new agreement could allocate water resources based on the highest valued use. Determining the value of water for different uses in Central Asia serves as a basis for compensation among the republics.

The United States Agency for International Development's Environmental Policy and Technology Project calculated the water value for different uses in the Central Asian Republics. The project-extrapolated values using three methods; (1) production function to compute a value for water as a productive input (the value of its marginal product), (2) directly survey willingness to pay, and (3) determine the cost of alternative supplies (Anderson 1997). Three assumptions used to calculate prices and values were the following (Anderson 1997):

- Water is a scarce resource within the region;
- Water should be allocated to achieve the greatest benefit to the region;
- Reasonable payments should be made by those who gain from such allocations to those who otherwise would be made worse off.

The valuation techniques and the three assumptions were used to assess the value of water for Central Asia Republics. The republics use water from the Syr Darya River for the generation of hydroelectric power, irrigation, municipalities, industry, and in-stream flows to the Aral Sea (Anderson 1997). The calculated values represented estimates with varying levels of uncertainty due to such parameters as poorly characterized municipal and industrial demand, possible water conservation measures, variable soil productivity, and world data used to determine municipal use and industrial use because Central Asian data was not available.

Valuation of Water

Hydropower

The value of water used for hydropower correlates with the value of water at the generation stations. The electricity generated per m^3 through the 430-meter cascade is 1.02 kWh. In the region power sales by the Kyrgyz Republic values hydroelectricity as 1 kWh equals $0.045. The difference between cost of producing hydropower and thermal power, or $0.01 per kWh, assesses the net benefit of hydropower. Factoring in the difference in value between summer and winter hydropower, the value of hydropower per m^3 of water used from the Syr Darya was between $0.015 and $0.01/$m^3$.

Irrigation

The value of irrigation water was determined by examining the effect of additional water on crop yield and the corresponding effect of additional water on farm revenue. The value of water varied depending upon the crop and the productivity of the farm. By using the estimates of the per-hectare value of crops produced in Central Asia and dividing that by the amount of water used per hectare in their production, water values for three crops were determined at between $0.06-0.10 for cotton, $0.0-0.04 for wheat, and $0.0-0.12 for rice.

Municipal use

Data for the Central Asian Republics municipal water use was unavailable. Using world data, the value was calculated by dividing the price of water per m^3 by the cubic meters used per household per year. Domestic consumption was valued at between $0.03 to >$0.15/m^3.

Industrial use

The value assessed to industrial uses of water is dependent on the type of industry and the industry's ability to reuse the water. Lacking data on industrial use of water within the Central Asian Republics, world values were substituted. World data assesses industrial use of water to exceed $0.1O/$m^3$.

Aral Sea as a Consumer

The United States Agency for International Development's Environmental Policy and Technology Project conducted a damage assessment ofthe Aral Sea Basin. The project

suggests water flowing into the Aral Sea is valued at $0.025 to $0.05 per cubic meter.

Agreement Scenarios

Valuation of water based on use by the Central Asian Republics aided the development of three agreement scenarios. When negotiating an agreement, investigators focused on the conflict between Uzbekistan and Kazakhstan irrigated agriculture and the Kyrgyz Republic's desire to increase hydropower generation.

Three agreement scenarios examined water allocation options for the republics that rely on the Syr Darya River for their water resources. To evaluate the three agreement scenarios, a mathematical optimization model aided the identification of an efficient and sustainable water allocation scenario. The model considers the water management objective of hydropower generation in the upstream country (Kyrgyz Republic) and irrigation water supply in the downstream countries (Kazakhstan and Uzbekistan). The model includes the following objectives that may each receive different weight depending on the option being analyzed (McKinney 1997):

- Maximize total power generation during the planning period;
- Minimize power deficit in winter periods;
- Maximize satisfaction of irrigation water demand; and
- Evenly distribute water deficits to irrigation districts.

Primary model data included; (1) water supplies (including surface water and groundwater), (2) water storage facilities (reservoirs), (3) water demand data (including irrigation and Aral Sea flow), and (4) energy demand data for the Kyrgyz Republic (McKinney 1997).

The model evaluated three scenarios, each with a different objective:

1. Satisfaction of irrigation demands;
2. Satisfaction of irrigation demands and Kyrgyz power demands; and
3. Maximization of power production.

All scenarios assumed at least a 7.17 km^3/year flow to the Aral Sea. All reservoirs in the basin presumed to be full at the beginning of the modeled period (five years). With each scenario, several items were calculated: the total supply and deficit of water to agricultural production, the total amount of power generated and any resulting deficit of power, the net benefits resulting from agricultural production, power generation and the flow to the Aral Sea, and the volume of water in storage at Toktogul reservoir after two growing (vegetation) seasons. Table 4 displays the results of the scenario analyses.

Irrigation Scenario

The irrigation scenario provides the largest amount of water to the agricultural sector while creating the greatest net benefits of all scenarios. Irrigation districts share evenly the 5.5 km^3 agricultural water deficit (in terms of percent of total demand). In February a 108 GWh power deficit occurs. Power surpluses occur during March, April and May. This scenario stores as much water as possible in the Toktogul reservoir to release for downstream irrigated agriculture.

Irrigation + Power Scenario

The irrigation + power scenario creates a 5.8 km^3/year agricultural water deficit. No power deficits occur under this scenario. The operating scheme of this scenario provides that downstream reservoirs are operated in conjunction with Toktogul reservoir to capture and store water released from Toktogul reservoir for power generation in the winter period for later release for agricultural production. Increased agricultural water deficit may be offset by increases in irrigation system efficiencies.

Power Scenario

This scenario creates the largest amount, 10690 GWh/year, of power generation for the Kyrgyz Republic. An agricultural water deficit of 6 km^3/year and during peak electricity periods a deficit of 2265 GWh/year occurs. Draining the Toktogul reservoir is necessary to make large power generation releases. After two years the Toktogul reservoir could be reduced to its dead volume of 8.55 km^3. The Toktogul reservoir took approximately ten years to fill after its construction. Refilling the reservoir requires operation in the irrigation mode during several years of high flows in the basin.

Goals of the Agreement

The Central Asian Republics' aim to create an integrated water management agreement that reduces conflict and provides maximum net benefits to all countries in the Syr Darya Basin. A natural resource management agreement of the Syr Darya's water flow should satisfy the needs of irrigated agriculture in Uzbekistan and Kazakhstan while creating hydropower electricity for the Kyrgyz Republic. The Heads of Kazakhstan, the Kyrgyz Republic and Uzbekistan declared the following objectives for an international agreement (Kasymova 1999):

- The countries of transboundary watercourses have sovereign rights to use their water and energy resources in accordance with their policies in the area of environmental protection and development, and they are responsible for the activities that will not inflict damage to the environment of other countries;
- It is essential to plan rational use of water and energy resources taking into account demands of economic development of the countries;
- An agreed approach to the use of water and energy resources of the Toktogul cascade of hydropower plants should be introduced considering mutual economically justified supplies of electric power, gas, coal and petroleum products;
- Improved use of water and energy resources of the Syr Darya basin will facilitate the solution of environmental problems in the Aral Sea basin.

On March 17, 1998 the head of the governments of Kazakhstan, the Kyrgyz Republic, and Uzbekistan signed, "The Use of Water and Energy Resources of the Syr Darya Basin," the first multi-year, multi-state agreement involving water sharing among the Central Asian Republics. The agreement utilized one scenario regarding management of the Syr Darya basin.

Appendix I

"The Use of Water and Energy Resources of the Syr Darya Basin" signed by the Prime Ministers of three Central Asian Republics followed the irrigation + power scenario. Examining the value of the different water uses in conjunction with the stakeholders' positions, this scenario satisfied many of the Central Asian Republics' concerns. The agreement contains information on the water release schedule of the Toktogul reservoir and energy transfers of the associated gas, coal, fuel oil and electric power supplied by the downstream countries to the Kyrgyz Republic. Provisions ofthe agreement include the following (Kasymova 1999):

- 2.2 billion kWh of power from the Kyrgyz Republic transferred to Uzbekistan (1.1 billion kWh) and Kazakhstan (1.1 billion kWh) during the growmg season.
- Under the condition of mutual compensation, Uzbekistan delivers during the year 772 million cubic meters of natural gas and 20 thousand tons of fuel oil to

the Kyrgyz Republic.

- Kazakhstan supplies the Kyrgyz Republic with 566.7 thousand tons of coal and 250 million kWh of electric power.

Assessment of the actual 1998 fuel transfers among the republics indicates that each republic augmented the delivery amounts. The actual supplies for 1998 were the following (Kasymova 1999):

- Uzbekistan supplied 747.9 million cubic meters of natural gas (the annual plan was 772 million cubic meters), and 23 thousand tons of fuel oil (the planned amount was 20 thousand tons).
- Kazakhstan supplied 150.4 thousand tons of coal instead of 566.7 thousand tons, according to the plan, 150 million kWh of electricity (with the annual plan of250 million kWh).
- The Kyrgyz Republic transferred 489 million kWh of electricity to Uzbekistan (with the annual plan of 1.1 billion kWh) and 468.6 million kWh to Kazakhstan (with the annual plan of 1.1 billion kWh).

The Kyrgyz Republic depicts that favorable hydrological conditions decreased water demands for irrigation, thus creating less electricity to transfer to Uzbekistan and Kazakhstan. The decrease in water consumption resulted in Uzbekistan and Kazakhstan delivering less electricity producing materials for the Kyrgyz Republic's wintertime electric needs.

The 1998 agreement among the Central Asian Republics failed to address the republics' water use and needs based on consumption. Further agreements should address mechanisms to compensate in situations when the obligations of the agreement are not met due to changed water management circumstances. The mechanism should prevent negative consequences such as 1998, when water abundance altered the transfer of natural resources among the Central Asian Republics. A water and energy use agreement among the Central Asian Republics developed a living document to satisfy the needs of sovereign nations. Further dialogue among the Central Asian Republics will advance the effectiveness and equity of water management of the Syr Darya Basin.

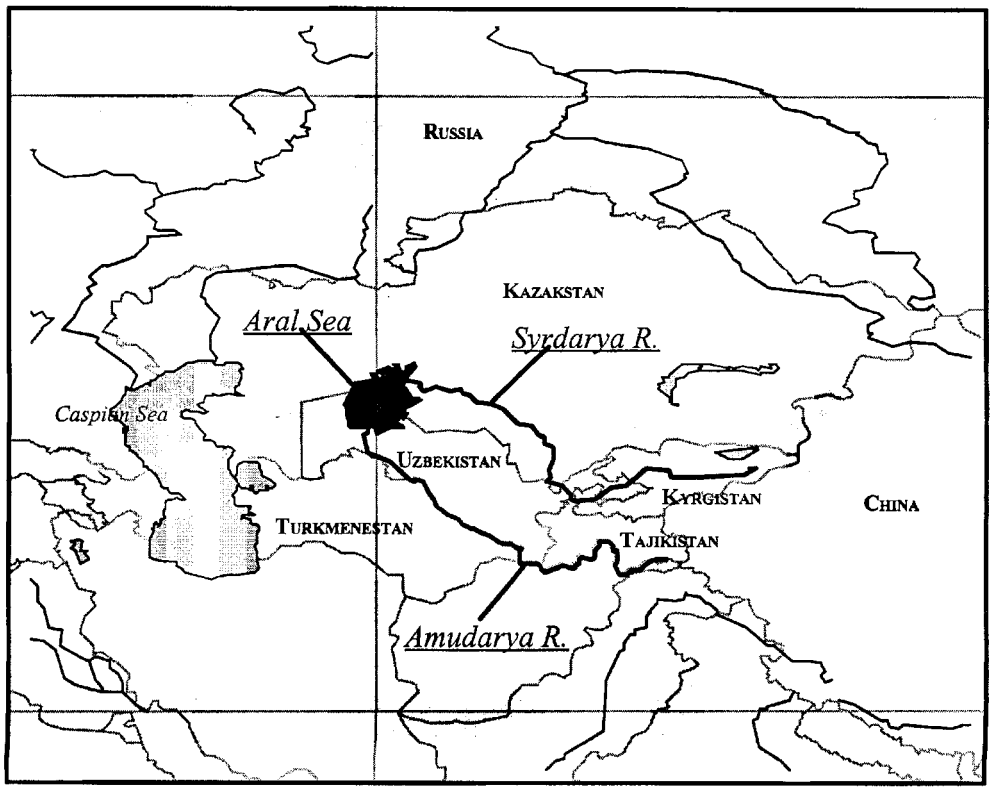
Appendix I (cont.)

Limited by the transitional economies of each republic, the agreement among Central Asian Republics requires further development of water valuation and pricing. The Central Asian Republics recognize that the natural resource from the Syr Darya River has value. After assessing the value of water uses among the Central Asian Republics, the signed agreement was largely based on bartering among republics for natural resources. The bartering technique allowed republics to simplify the management planning process, although contingency plans that address fluxuations in each republic's seasonal water demands were not discussed. Using a bartering system to resolve conflict among the republics did not sufficiently assess the true value of water. Essentially, the agreement was influenced by Soviet principles of sharing resources for the equal betterment of all republics.

As each republic constructs independent economies, the region should strive to create a functioning market for the products the system generates, or in the absence of privatization and markets, estimators of the values which water generates (Keith 1997). The 1998 agreement among Central Asian Republic used a rudimentary valuation of water to minimally assist the allocation of Syr Darya water usage. As the economies of Uzbekistan, Kazakhstan and the Kyrgyz Republic grow stronger, the sovereign countries

should strive to create international water management agreements that use market principles.

Figure 3 -Map of the Aral Sea Basin



Adopted From:
McKinney, Daene. 1997. Sustainable Water Management in the Aral Sea Basin. Department of Civil Engineering -The University of Texas at Austin.

Table 1 - Aral Sea Statistics

	Until 1960	By 1990
Area	66,00 sq. km	33,000 sq.km
Volume	>1000 cu.km	330 cu.km
Inflows	47-50 cu.km/annually	9-12 cu.km/annually
Level	50-53 meters	38 meters
Water Use level	63 cu.km/annually	117 cu.km/annually
Water Salinity	10 g/1	30 g/1

Table 2 - Water Allocation and Use for Amu and Syr Daryas by Republic

Country	Water Allocation 1994-1995 (cu.km)	Water Use 1994
Kazakhstan	8.2	10.9
Kyrgyzstan	0.2	25.1
Uzbekistan	32	58.6
Aral Sea	25	19.3

Table 4- Results of Three Modeled Scenanos

	Irrigation	Irrigation + Power	Power
Agriculture (km3/year)			
Supply	38.3	37.9	32
Deficit	-5.5	-5.8	-11.8
Power (GWh/year)			
Generated	9656	9752	10690
Deficit/Surplus	-108	0	2265
Net Benefits (million $/year)			
Agriculture	3715	3703	3165
Power	95	98	84
Aral Sea Flow	269	269	269
Total	4079	4069	3518
Toktogul Storage (km3)			
At the end of 2 vegetation periods	12	9	3

Table 5 -General Statistics of the Aral Sea Basin Countries

	Kazakstan	Uzbekistan	Kyrgyzstan
Area, km2	2,717,300	447,400	198,00
Irrigated Land, km2	23,080	41,500	10,320
Population, 10 to the 6th	17,376,615	23,089,261	4,769,877
Population Growth			
Rate,%	0.62	2.08	1.5
Life Expectancy	68.2	68.8	68.1