SUSTAINABLE WATER MANAGEMENT IN THE ARAL SEA BASIN

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Introduction

This paper addresses issues regarding the institutional developments necessary to allow sustainable water use strategies to be elaborated and implemented in the Aral Sea basin. The technical problems of formulating alternatives for water and environmental management in this region can likely be solved by the well trained, knowledgeable, and capable specialists of the region with the help of the various international aid programs currently operating there. However, many questions remain about the ability of decision makers to represent the goals of the region's citizenry in developing these solutions and the capacity of the region's institutions to effectively carry them out. These comments are offered as observations after a period of personal interaction with researchers involved in trying to understand and develop solutions to the water and environmental problems facing the Aral Sea basin countries. While I am not proposing answers to these problems, I will raise several questions regarding the need for and the type of institutional developments necessary to allow sustainable water use strategies to be realized in the Aral Sea basin.

The Aral Sea Basin lies within the Newly Independent States (NIS) of the Former Soviet Union of Kazakstan (Kyzl-Orda and Chimkent oblasts), Kyrgistan, Tajikistan, Turkmenestan, and Uzbekistan (See Fig. 1). The Aral Sea Basin is bounded on the west by the Caspian Sea and on the east by the Kopet-Dag, Pamir, and Tien Shan mountain ranges. Table 1 lists various statistics of the countries of the region (CIA, 1995). The basin consists of desert, foothill, and valley regions with low precipitation and high evaporation, and high mountain areas with high precipitation and low evaporation. The Aral Sea, a key hydrologic feature of the basin, receives the bulk of its water from the two major rivers of the region, the Amudarya (2,600 km, draining 692,300 km^2) and Syrdarya (2,212 km, draining 493,000 km^2), with a combined average annual flow of 115.6 km^3. The average annual river flow to the Aral Sea from 1927-60 was 55 km^3, whereas, due to large diversions of water for irrigated agriculture, from 1975-85 it had dropped to 10 km^3(Gleick, 1993).

During the mid-1700's to 1960, the Aral Sea level was approximately constant at about 52 m AMSL (above mean sea level), with fluctuations of as much as 4 - 4.5 m. However, during the period 1960 - 89 there was a 14 m decline in the Aral Sea level and a decrease in surface area of 65,000 km^2 (See Fig. 2). This reduced surface area of the Aral Sea resulting from the sea level decline is one of the few anthropogenic effects on Earth which is visible from space. Table 2 shows the water balance for the Aral Sea over the past several decades indicating the dramatic loss of storage in the sea from 1960-90 (Turkestan-Our Common Home, 1995). In fact the sea has actually split into two seas, the Large and Small Aral Seas.

This massive decline in the inflow to the Aral Sea has created a myriad of social, economic, and environmental problems. These include increased salinity of the sea; a reduced moderating effect of the Aral Sea on local climate, resulting in hotter summers, colder winters, and a decreased growing season; and increased irrigation requirements for salt-laden fields in order to achieve the same level of production as before. To satisfy this increased irrigation need, more fresh water has been taken from rivers that otherwise would feed the Aral Sea, resulting in a cycle causing even greater depletion of the sea. As the lake continues to recede, more and more of the salty, barren sea floor is exposed-currently more than 20,000 square kilometers. Based on water balance calculations, restoring the Aral Sea to its pre-1960 size would require an annual inflow of about 53 km^3, while stabilizing the Aral Sea at 40-41 m would require an inflow of 35 km^3/yr (Micklin, 1992).

The agricultural production and irrigation decisions and the environmental, economic, social, and political problems of the Aral Sea basin are linked together in a tightly knit system. The national boundaries of the Aral Sea basin states do not stand in the way of the region's environmental problems. The individual republics of the region cannot solve their environmental and economic development problems without the cooperation of the other nations. The upstream countries' interests (e.g., Kyrgistan's and Tajikistan's winter-time hydroelectric power generating releases) are often at odds with those of the downstream countries (e.g., Kazakstan's,

Turkmenestan's, and Uzbekistan's summer-time irrigation releases). Under the Soviet system, this conflict was an intranational issue and water use strategies were developed that maximized the perceived benefits to the entire region.

The situation changed dramatically upon the break-up of the Soviet Union in 1991. Since that time, the countries of the region have been struggling to realize their full potential under independence. Each republic has been operating independently of the others, and international treaties are often negotiated to resolve conflicts over natural and water resources. A high level of technical ingenuity exists in the Aral Sea region, and cooperation between the republics of the region is a stated goal of their heads of state. Recently, it has been recognized that developing and implementing water use strategies that consider the goals of all the basin nations will result in greater benefits to the whole region.

The Nukus Declaration, signed by the heads of state of the Aral Sea basin nations in 1995, indicated the need for a "unified multi-sectoral approach and the development of cooperation amongst the states and with the international community." This declaration provides a "commitment to sustainable development" recognizing water and biological resources as the basis for future sustainability; a need for a scientifically based system of agriculture and forestry; increased irrigation efficiency; economically driven methods of water usage; improved technologies in irrigation and environmental protection; and incentives for long-term land and water management. In light of the desire for sustainable resources development, it is important that we consider the elaboration and implementation of sustainable water resource strategies for the region.

Sustainable management strategies have been defined by many groups, such as the "Bruntland Commission," as

> *those that meet the needs of the present without compromising the ability of future generations to meet their own needs*

where the essential needs of the poor should be given priority, and limitations are imposed by technology and social organization on the environment's ability to meet present and future needs (WCED, 1987). Recently, the joint UNESCO/ASCE committee on Sustainable Water Use Strategies (Loucks et al., 1996) has defined sustainable water resource systems as

> *those that fully contribute to the needs of society, now and in the indefinite future, while protecting their cultural, ecological, and hydrological integrity.*

In order to achieve sustainable water use in the Aral Sea basin, several decisions must be made, including (but not limited to): the amount of water to be used for agricultural purposes, the price of water, and how water should be apportioned among non-agricultural users. However, these decisions cannot be made until several fundamental questions are answered regarding water allocations in the Aral Sea basin, including: Can the Aral Sea be saved? Can its level ever be raised again, even in the distant (> 25 years) future? How much land can be sustainably irrigated, and by what methods? What are the appropriate crops that can be grown with the water that is likely to be available? Is food security a major priority for the basin nations? What are the appropriate institutions for managing water in the region?

Aside from these mostly technical questions, another important factor that must be considered is the need for adequate legal, social, educational, and economic systems and institutions for developing water use strategies that meet the goals of the people of the region. This is a very important problem in this region, given the previous nonrepresentative, nondemocratic, centrally planned system that existed under the Soviet government. Citizen input under that regime was not solicited, encouraged, or in most cases even allowed (Allworth, 1990).

Background and History

A typical assumption about current water use strategies in the Aral Sea basin is that there is no possibility of returning to the water policies of previous times. While this may indeed be true, perhaps studying those earlier water use strategies may teach us some important principles necessary to develop sustainable water use strategies for this region.

Sustainable water resource systems historically existed in the Aral Sea basin under traditional practices in which local systems operated independently in separate basins, each drawing water from separate sources by means of indigenous technology. For example, many of the traditional farms in the region tended to be small, carefully managed irrigation fields with walls around

fields that acted as salt accumulators, preventing salinization, and the trees lost sufficient water to evapotranspiration to prevent waterlogging and drainage runoff, thus avoiding many of the modern irrigation problems (Micklin, 1992). Unlined canals and primitive water distribution systems were used. Water was not transported over large distances, but was used locally or allowed to flow downstream in the natural watercourse. Per hectare water withdrawals were lower than today, crop yields were higher, and loss of soil fertility, secondary soil salinization, and heavily salinized drainage flows were not serious problems. Management policies were developed and implemented by local entities. These traditional practices involved independent management of separate irrigation systems and tended to localize conflicts (Gleason, 1991; Wheeler, 1964). Regional conflicts related to water use did not exist.

We can trace the causes of the deterioration of traditional, and sustainable, water use in the Aral Sea basin back to the time following the Russian conquest of Central Asia in the latter part of the nineteenth century. Central Asia, at that time, was seen by the Tsarist government as an almost unlimited source of agricultural production and natural resources. The Tsarist government conceived of the wholesale replacement of traditional methods of irrigation based on small farms by much larger-scale irrigated enterprises. However, they tried and mostly failed to implement several large-scale irrigation projects in the region (Wheeler, 1964).

Following the 1917 Bolshevik revolution, the Soviet government initiated work on large-scale irrigation projects to secure USSR cotton independence. Much of this work was not begun until after the civil war had ended with Soviet domination of the region in 1921. Under this new regime, control of water resources was taken away from local citizens and vested with central planners in Moscow. Soviet water planners divided Central Asia into water-related administrative units that ignored watershed boundaries. Many have suggested that the purpose of this division was to eliminate and prevent any dissension to Soviet rule from developing in the region (Wheeler, 1964; Allworth, 1990). Under this regime, irrigation systems were greatly enlarged, previously sustainable farming units were collectivized into large collective farms (kholkoz) resulting in highly integrated resources and needs. This specialization led local groups and their industries to become elements of a much larger system, destroying local sustainability (Micklin, 1992). The traditional water management practices of the region were modified substantially, resulting in unsustainable systems, declining effectiveness of irrigation systems, and mismanagement of the region's water resources. The irrigation system links the major drainage basins of the region and the upstream and downstream users. The result is that the cities, villages, and even river basins of the Aral Sea basin, and the nations comprising it, form an integrated economic-ecological system. The dependence of local groups on the larger system has greatly affected the sustainability of the entire system.

A widely held belief among water planning specialists of the former Soviet Union is that the root cause of the deterioration of water resources and the environment in the Aral Sea basin is the result of an incorrect economic development strategy allowed in the region since the late 1950's. Since that time, substantial increases in diversions from the basin's rivers to agricultural production were realized, which focused excessively on the increased output of irrigated cotton and rice at the expense of needed food production (Kotlyakov et al., 1992). These diversions eventually resulted in the desiccation of the Aral Sea, extensive environmental and economic damage, and regional conflict over access to the scarce water resources of Central Asia (Gleason, 1991).

Micklin (1992), on the other hand, has argued that the causes of the Aral Sea problem extend back to the introduction of modern irrigation techniques in the region in the mid-1920's, along with collectivization in the 1930's that led to the destruction of the small-scale traditional irrigation systems and created large state-run enterprises. This situation led to the original destabilization of irrigation, lowered water use efficiency, and other problems. In the 1950's, further expansion and mechanization of irrigation in the Aral Sea basin lead to even larger farms and further lowering of irrigation efficiencies. During this period, the eventual shrinkage of the Aral Sea was recognized and justified on the basis of the tradeoff between perceived larger economic benefits from diverting water for irrigation and the resulting cost of environmental damage, which was assumed to be minimal (Micklin, 1991).

However, the large irrigation water diversions from the Aral Sea basin rivers have continued up to the present time and the attendant social, economic and environmental problems have increased. The problems of the Aral Sea basin are so severe and threaten such a large population (approximately 55 million) that international attention has recently focused on the area with the hope of remediating environmental devastation

and stabilizing the shrinking sea, once the world's fourth largest freshwater lake. Shrouded for decades, the Aral's plight became known to the world in the late 1980's. Following the collapse of the Soviet Union in 1991, the world community has responded: financial aid has been provided from, among other sources, the US Agency for International Development, the United Nations Development Program, the European Union, and the World Bank. The World Bank is providing more than $470 million for seven Aral Sea projects (World Bank, 1995), which are being carried out by researchers from Europe, the Central Asia, and the United States.

Recent studies of the Aral Sea problem have found that (1) the Aral Sea as a biological entity has vanished and that it is an illusion to think that it can be restored to its former grandeur, (2) the main task facing the region is to preserve the Aral Sea's present size and ameliorate adverse impacts, (3) information upon which to base restoration efforts is lacking, (4) irrigation efficiencies in the region can be increased, and (5) irrigation drainage in the region can be channeled to the Aral Sea. Most specialists agree on the need for restructuring and reorienting the economy, introducing water pricing and metering, vertically integrating the cotton industry, conserving irrigation water, rehabilitating irrigation systems, assuring food security, improving drinking water quality, and implementing a broad range of environmental health and medical care measures (Kotlyakov et al., 1992).

With the help of the United Nations Environment and Development Programs and the World Bank, a program has been developed to address the crisis in the Aral Sea basin. The program includes plans to mitigate the impacts of environmental degradation, to develop sustainable water management strategies, and to develop regional institutions with the capacity to implement the program (World Bank, 1995). The key organization for developing and implementing the policies and programs of the World Bank program is the Executive Committee of the Interstate Council for the Aral Sea (a body of high-level representatives of the basin states). Groups of local experts (senior specialists from the government, technical institutes, and the academies of science) are working with the Executive Committee to help develop and coordinate the program. The centerpiece of the program is the development of a regional water resources management strategy. The program has four objectives: (1) to stabilize the basin environment; (2) to rehabilitate the disaster zone near the sea; (3) to improve the management of international waters in the basin; and (4) to build the capacity of the regional institutions to plan and implement the program.

It is evident that the technical needs of the region for water and environmental management will be addressed under the World Bank program. However, a strong tradition exists, even today, in the Aral Sea basin countries for compartmentalized planning, managed by a strong centralized government with little or no citizen input, and very little legislative or judicial oversight or review. Under this system, many different agencies collect and analyze data without much knowledge of, or communication with, other agencies or institutions. In addition, almost no mechanism exists for true, independent peer review or public comment on proposed water use strategies. One of the main problems with this system is that it calls for continued, strong centralized planning. If the local communities and the many design and research institutions of the region are not fully included in this process, then the mistakes of the past are likely to be repeated in this region. Under the World Bank program, some progress has been made in assessing the social needs and priorities of populations affected by the program's projects. These assessments are in the form of surveys of individual households and community groups and focus group discussions with community leaders. The information collected from these surveys is being used to guide the design of projects.

Requirements for Sustainable Water Use Strategies

The conventional "meet the requirements" approach to water resources allocation, where water use strategies are formulated to accommodate projected population growth and economic development with minimal consideration of ecological carrying capacity or water resource availability, often fails to achieve sustainability (Loucks et al., 1996). The notion implicit in this type of planning is that adequate supplies will somehow be found to serve the populations that develop over time. In the Aral Sea basin situation, this may be tantamount to waiting for Siberian river water to arrive. Siberian river diversion was proposed to supply about 27 km^3 from the Irtysh and Ob rivers to the Aral Sea basin by the year 2000, but the project was canceled by Soviet authorities in 1986. In large part, the water allocation decisions in the basin today continue to rely on plans which anticipate the eventual delivery of this water, an almost impossible economic and political eventuality.

The problems of water resources allocation in the Aral Sea basin must be considered in an integrated, holistic, multi-disciplinary, regional manner. The intimate connection between the technical water planning problems and the socioeconomic conditions of society must also be considered as well. A framework for the development of such sustainable water use strategies has been proposed by Loucks et al. (1996):

- Define the area of concern
- Involve stakeholders
- Develop a shared vision of future conditions
- Characterize the system (economic, environmental, and social) conditions and trends
- Establish goals and objectives
- Develop an action plan to achieve goals
- Monitor conditions and evaluate results
- Adapt management as new information becomes available

While some of these points are being addressed in the current planning efforts in the region, many are also lacking or absent, such as stakeholder participation.

For sustainable water use strategies to be developed for the Aral Sea region, they must be compatible with economic, energy, environmental, and social development problems. The following concepts are derived from the "Bruntland" report (WCED, 1897) and rephrased in terms of the Aral Sea basin situation:

Accountability. The various agencies of the region who are responsible for managing the region's resources must be made directly responsible and accountable for ensuring that appropriate and sustainable water use strategies are developed and carried out. True responsibility and accountability were absent from water resources decision making under the centralized Soviet government. Accountability must be ensured in any new programs and policies adopted in the region. Where is the accountability in the current organizational structure? Who is accountable to whom? Where is the reporting and accountability to the legislature, judicial system, and the citizenry?

Effects. While accepting assistance from international development agencies and non-governmental organizations (NGO's) to strengthen institutions, the countries of the region must reinforce the roles and capacities of environmental protection and resource management agencies. Do these agencies really exist in the Aral Sea basin? What authority do they operate under? Are the laws and regulations that may protect the environment enforceable? Is there going to be adequate inspection to ensure compliance with the regulations? Are credible and adequate data being collected to allow the quantification and analysis of the effects of the various legislation and regulations?

Risks. The capacity to identify, assess, and report risks of irreversible damage to natural systems and threats to the survival, security, and well being of the regional community must be reinforced and extended. There must be an independent, complementary capacity to assess risks that is free from political influences (to the extent possible). Models and other decision support tools can aid in developing the region's ability to assess risk and design robust and resilient water resources strategies. However, there must be a system of scientific and technical peer review to ensure that credible and worthwhile scientific and engineering data and techniques are being developed and used to produce these risk assessments. This will require close cooperation among NGO's, scientific bodies, and industry groups to develop a system of open reporting and commenting on the techniques and data used to develop alternatives for water use.

Choices. The widespread support and involvement of an informed public, NGO's, scientific community, and industry is necessary to make decisions necessary to achieve sustainable water use strategies. The rights, roles, and participation of all stakeholders affected by development and planning, decision making, and project implementation must be elaborated and expanded. An open and participatory process of selecting among alternatives has been absent in the Aral Sea region in the past. Will it be part of the plans being developed at present? The World Bank program does include a social assessment component, but it is not clear that a true system of public comment and participation is being developed. How can these issues be dealt with in a region where true democratic participation has been absent for well over 70 years?

Legal system. Legal systems must be established in the

region that recognize the rights of present and future generations to an environment adequate for their health and well being. What sorts of laws are being developed to deal with the natural resources of the region? Can these laws adequately deal with sustainability issues? What procedures are being developed to deal with dispute resolution?

Investments. Often, the costs of remediating ecological damage exceed the investment costs of environmental protection and improvement needed to prevent such damage. Financial institutions and governments involved in the region must reinforce the need to invest in these programs. True costs, based on non-Marxist philosophies (assuming that this is the economic direction that the citizenry choose to pursue) must be developed and used in decision making. Under these circumstances, actions can be taken to achieve developmental and environmental progress, but it cannot be sustained upon a deteriorating environmental base. The costs of environmental damage must be accounted for if environmental restoration or protection is to be achieved. Economics and ecology must be fully integrated in decision making and lawmaking processes to protect the environment and promote development. Many questions about the investments in Aral Sea basin water use strategies must be answered before any plans can be adopted. Are all costs associated with a plan considered? Can the service provided by a project pay for itself? Will the revenues exceed the costs and provide improvement and maintenance of the project? What happens after the funding agency has withdrawn? This issue is very important for the Aral Sea basin. Is centralized planning in Moscow being replaced by centralized planning in the World Bank and its funded partners, or is capacity being built that will sustain the institutions and systems put into place?

Education and empowerment. A local populace knowledgeable about ecological and water resource problems is critical to the achievement of sustainable water use strategies (Loucks et al., 1996; WCED, 1987); the local populace must perceive their stake and have a say in the decision making process. The general citizenry must have adequate knowledge with which to make reasonable choices among the alternatives developed for water use. There is a tremendous base of highly educated and trained people in the Aral Sea basin; however, there is no recent history of ecological or socioeconomic decision making by the general populace of the region.

Access. The availability of resources and an equitable distribution of costs and benefits are essential aspects of the development of sustainable water use policies in the Aral Sea region. In the past, costs were not a major factor in the agricultural production decisions, and the revenues generated by the sale of agricultural products were not directly available (and in many cases were not even known) to the persons involved in the production at a local level. Farmers must learn to understand the effects of their farming decisions. They must also learn the true costs and benefits resulting from their decisions. This does not exist in the Aral Sea basin today except in a few cases. On most farms, information on the revenues derived from the sale of crops is not available to the farmers who actually produce them. It is questionable whether the costs of production are known to most farmers either, with fixed quantities of funds and resources supplied from the central government. These farmers must become aware of available technology for water management and irrigated agricultural production. They must understand their impact on the hydrological and biogeochemical cycles and on the ecology of the watersheds in the basin. Changes must be made to ensure that data and knowledge are made available to those persons involved in making the production decisions. What institutions and/or policies are being developed to ensure that the persons affected by the environmental consequences of those agricultural (water allocation) production decisions are fully represented and involved in the process?

The region's environmental management and socioeconomic development goals must be defined in terms of sustainability. What are the "goals" of the Aral Sea basin nations? Who will define these goals? Who will be responsible for ensuring that reasonable strategies are developed to achieve these goals? Who will be responsible for monitoring the long-term success or failure of these attempts?

Decision Support for Sustainable Water Use Strategies

Very little has appeared in the published literature about modeling or decision support tools for sustainable

water resources management. Many questions remain unanswered as to how to incorporate sustainability measures into water and environmental resource models. Several measures of sustainability have been proposed; perhaps the one that is most appealing from a water systems modeling perspective is the one suggested by Loucks et al. (1996), whereby the net welfare derived from alternative strategies is required to be a monotonically increasing function over time. In addition, several statistical indices are available to measure the sustainability of a project: reliability (probability that a sustainability criterion is within a range of acceptable values), resilience (probability that an unsatisfactory sustainability criteria value is followed by a satisfactory value), and vulnerability (extent or duration of system failures). If statistical indices of sustainability can be defined, they can be combined in a multiobjective framework to arrive at an overall measure of sustainability. In determining the sustainability of water resource systems, time horizons must be long enough so that allocations to present generation users are not affected by the length of the horizon or the terminal conditions. Only the solution for the first few periods is of real interest; future periods can be much longer and time periods can be aggregated. Modeling procedures should be sequential and adaptive. What, if any, is the appropriate interest rate to use in the Aral Sea basin models? Sensitivity analysis should be used to determine its effect on project selection. Too low an interest rate may cause marginal projects to become economically attractive even though they may not be sustainable (Loucks et al., 1996).

How do we define the rights of future generations? How will we know the objectives of future generations? As noted by Loucks et al. (1996), we cannot predict with confidence what future generations will want to do, or will value, but we can try to guess at what they might want and value. Including these guesses along with those of the current generation in a multiobjective planning framework allows us to identify tradeoffs in the benefits derived today and what we think descendants would like. Future decisions are conditional on the decisions that were made in all the preceding periods. However, at the present time we cannot alter the decisions that resulted in the current state of the system. We can examine the tradeoffs between present day objectives and future objectives, then decisions can be made today that take into account the objectives (perceived) of future generations.

Conclusions

There has been increased public awareness of the problems of the Aral Sea basin and the potential threats to the environment and the adverse consequences of those threats on the region's population. How to allocate and manage the available capital and resources of the basin in a manner which will improve the quality of life for the people in the basin and their descendants is one of the major issues faced in the region today.

The development of sustainable water allocation strategies for the Aral Sea basin requires consideration of not only economic, scientific, and technical aspects but also social and ethical aspects. Deciding what is to be done given what we know and determining how much cost and sacrifice are warranted, and choosing who is going to pay, are issues that need to be debated by the people of the region. Sustainability objectives must be included in the analyses, and these have been absent in the past.

The knowledge and techniques to analyze the problems of water supply and demand and to plan, design, and upgrade facilities that meet the needs for water of sufficient quantity and quality at reasonable cost exist in the Aral Sea basin. Water allocation in the Aral Sea basin may be achieved that will allow a reasonable level of agricultural production and perhaps even increase the annual flow to the Aral Sea. However, this policy may not take into account the desire of the population to move toward a more industrially based economy. Flexible, robust, and resilient water resource systems must be designed that can easily adapt to future changes in demands or purposes and recover and function even in the event of an unforeseen failure.

How can institutions and rules be changed to accommodate the gap between what now exists and what is desired? This is especially problematic in the Aral Sea basin where the institutions are in a state of financial collapse and, in fact, undergoing large-scale redefinition today. What are the appropriate forms of the resulting institutions? As suggested by Gleason (1991), perhaps a combination of centralized management and decentralized, democratic, and local management that feeds local decisions and priorities into the centralized system could be effective. The development of a truly representative and consensus driven water allocation and use strategy requires a highly knowledgeable population of water users.

Most societies of the world today are either too developed and set in their to enact the types of sweeping changes needed to achieve sustainable pathways to the future, or they are struggling to achieve a reasonable level of modern development such that they do not have the educational systems and infrastructure available to deviate from their current paths. In contrast, the Aral Sea basin countries have recently seen the collapse of their former, centralized, Soviet form of government which existed for the previous 70 years. There exists in the region a good infrastructure for economic development and education. Their failing economies are being restructured and major changes are being made in their institutions to achieve more free and democratic societies in the region. What better situation for achieving sustainable systems and institutions?

A unique opportunity exists in the Aral Sea basin today, but if it is not realized, this window may close. The political and social systems of the region are in a state of great flux and redefinition. The technological and scientific communities there have seen the need to redefine themselves to ensure a prosperous future for the region, while at the same time recognizing the effects of the decisions that have been made in the past. The Aral Sea basin presents itself in the late 20th century as a potential laboratory for sustainable development. The people of this region have a unique opportunity to lead the world in the development and application of the principles of sustainable water use and economic development.

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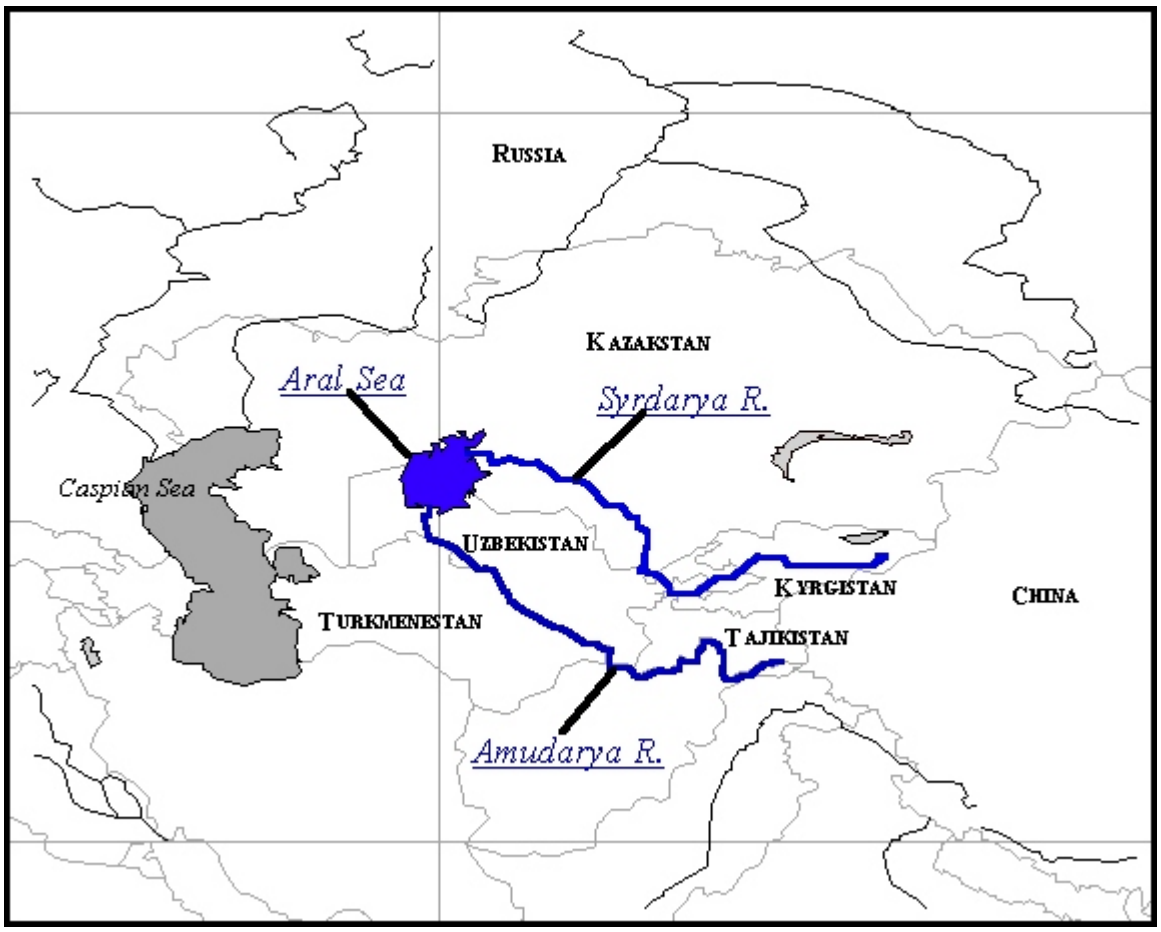

Figure 1. The Aral Sea region.

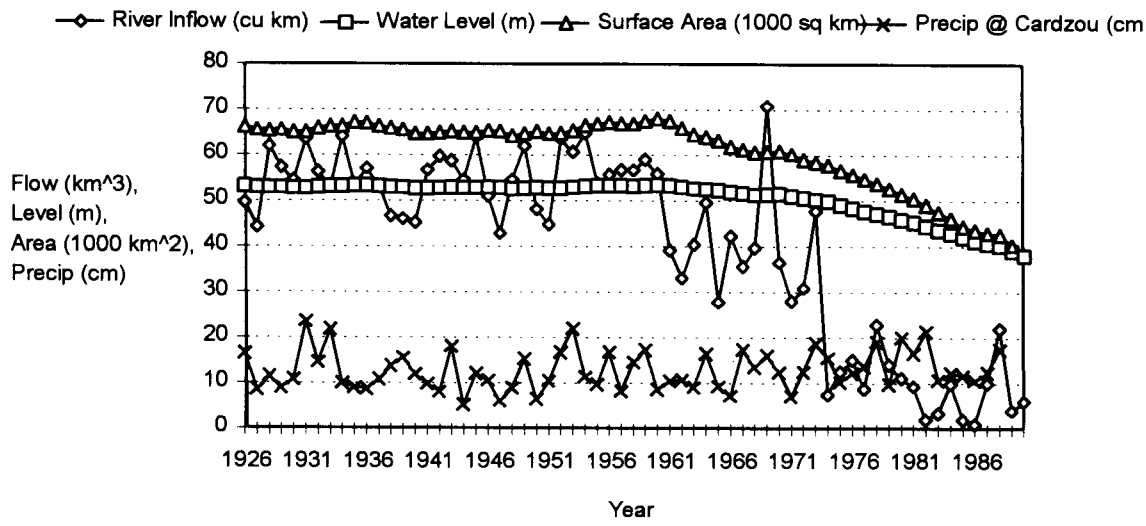

Figure 2. Aral Sea inflow, level, surface area (Gleick, 1993), and precipitation at Cardzou (pers. comm. P. Micklin, 1995) for 1926 to 1990.

Table 1. General Statistics of the Aral Sea Basin Countries (CIA, 1995).

	Kazakstan	Uzbekistan	Turkmenestan	Kyrgistan	Tajikistan
Area, km^2	2,717,300	447,400	488,100	198,500	143,100
Irrigated land, km^2	23,080	41,500	12,450	10,320	6,940
Population, 10^6	17,376,615	23,089,261	4,075,316	4,769,877	6,155,474
Pop. growth rate, %	0.62	2.08	2.5	1.5	2.6
Life expectancy	68.2	68.8	65.8	68.1	69.0

Table 2. Water Balance of the Aral Sea, km^3 (Turkestan-Our Common Home, 1995)

Time	**Input**		**Output**	**Change in Storage**
	Rivers & Groundwater	Precip	Evap	
1911 - 60	56.0	9.1	66.1	-1.00
1961 - 70	43.3	8.0	65.4	-14.1
1971 - 80	16.7	6.3	55.2	-32.2
1981 - 90	3.90	6.2	43.7	-33.6
1991 - 94	21.0	4.6	33.6	-8.00