THE ARAL SEA CRISIS:

THE INTERSECTION OF ECONOMIC LOSS AND ENVIRONMENTAL DEGRADATION

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Introduction

Bordered by Kazakhstan and Uzbekistan, the Aral Sea was the world's fourth largest inland body of water until the late 1960s; since then, it has dropped to sixth place. The ensuing environmental problems and economic losses resulted from the Soviet Government's economic development program focused on the expansion of irrigation and cotton production in an attempt to solve regional unemployment and to increase exports. While economic progress was achieved in the short run, it was done at the expense of the environment and long-term economic sustainability.

This paper evaluates how environmental problems in the Aral Sea basin have resulted from economic decisions that discount environmental consequences. It shows how economic advances were achieved at the cost of the environment, and ultimately created a negative feedback loop in which further attempts to advance the regional economy led to additional environmental damage and economic loss. Finally, the paper briefly examines actions that can mitigate the environmental and economic crises.

Background

The current environmental crisis revolving around the desiccation of the Aral Sea results from large diversions of water from the Amu Darya and Syr Darya Rivers, poor irrigation construction and maintenance, and mismanagement of water resources. The crisis began in the early 1900s when the Soviet Government initiated its threefold plan to expand irrigation in the region, to cultivate cotton for exportation, and to increase the standard of living for the region's growing population.

In accordance with this plan, the Soviet Government attempted to reconfigure land and water rights, and made major investments in agricultural production and water reclamation. Between 1925 and 1929, the government confiscated land, arbitrarily dividing it among users. Resulting widespread discontent led to the cancellation of the program and the development of cotton cooperatives. By 1932, land and water rights, as well as agricultural management programs, had been nationalized under mass collectivization programs that destroyed traditional agricultural practices and undermined water taxation programs. An extensive number of exemptions given to members of collective and state farms made the water tax even less meaningful and discouraged water conservation and efficient irrigation practices.[1] As a common property, open access resource, the Aral Sea was undervalued. Government policies violated the three basic tenets of an effective property rights system: exclusivity, transferability, and enforceability. Because a large percentage of profits were sent to Moscow, collectives had little incentive to conserve resources. In addition, water for irrigation was provided almost free. As a result, users of water did not bear all of the consequences of their actions, and water was not allocated efficiently; marginal net benefits were not equalized for all consumers.

Efforts to meet state-established production quotas led to over-farming, over-production, negligent irrigation construction, and the widespread use of pesticides aimed at increasing yields per hectare. During the 1930s, the Soviet Union became a net exporter of cotton by cultivating 90% of all irrigated areas in Central Asia and constructing irrigation canals that lacked adequate drainage systems. Subsequent soil salinization resulted in more land being abandoned than was brought into cultivation by newly built irrigation canals.

[1] Kobori and Glantz. 38.

During the 1950s, the state expanded and mechanized irrigation and farming. The opening of the Kara Kum Canal in 1956 resulted in the diversion of large amounts of water from the Amu Darya River, one of the two sources of water to the Aral Sea. The most important irrigation and water supply system in the former Soviet Union, the canal is built on loose sand. Associated seepage losses are so enormous, an 800 square kilometer lake formed alongside the canal.[2]

Although Soviet planners recognized that the major expansion of irrigation necessary for the cultivation of cotton would reduce inflow to the Aral Sea and substantially decrease its size, they considered the tradeoff worthwhile. Officials believed that, "a cubic meter of river water used for irrigation would be more economically beneficial than the same volume delivered to the Aral Sea."[3] Their calculations were based on, "a simple comparison of economic gains from irrigated agriculture against tangible economic benefits from the sea."[4] From their perspective, the tradeoff was essential in order to increase raw cotton production and exports, augment foreign currency earnings, and provide employment opportunities to the local population.[5] The use value of the Aral Sea exceeded the combined option and non-use values. In addition, many scientists believed that the Aral Sea had little or no impact on the region's climate, and that salt was unlikely to blow from the dried seafloor damaging agriculture and plant life. A widely accepted theory purported that the formation of a durable salt crust would prevent harmful compounds such as sodium sulfate and sodium chloride from depositing on the former bottom of the Aral Sea and becoming airborne. Finally, planners assumed

[2] Klozli.4.
[3] Stewart. 101.
[4] Micklin in *Science*. 1171.
[5] Glazovskiy. 73-74.

that they could alleviate potential water deficits by importing water from the Ob, Irtysh, and Volga Rivers via a series of canals. These erroneous suppositions permitted planners to ignore the probable reduction in size of the Aral Sea and subsequent environmental problems.

By the mid-1960s, cotton production had become the mainstay of economic development in the Aral Sea basin. However, fertilizers accounted for nearly half of each hectare's yield, irrigation canals became less efficient in delivering water to fields, and the per hectare application of water multiplied resulting in water scarcity. As industries dependent on the Aral Sea and the cotton monoculture grew less productive, it became apparent that economic progress was being achieved at the expense of the environment. Earlier assumptions that the destruction of the Aral Sea and expanded irrigation were justified by increases in cotton production came under question. It was soon obvious that cost-benefit analyses were based on faulty information, including lack of understanding of the effects of the cotton monoculture, improperly designed, built and maintained irrigation systems, inappropriate discharge of drainage water into rivers and lakes, faulty water management practices that discouraged conservation, and inadequate environmental research.[6] The analyses overestimated the benefits derived from irrigation, ignored externalities, and failed to differentiate between individuals benefiting from cotton cultivation and those harmed.

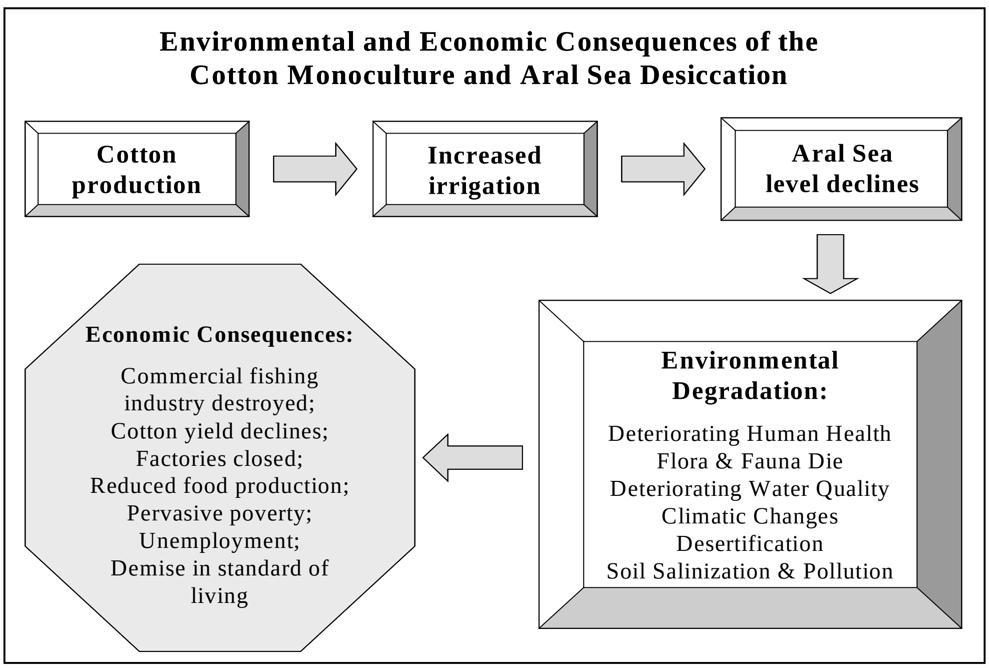
Environmental Degradation

The environmental troubles in the Aral Sea region are best understood as a creeping environmental problem (CPEs) which, "changes the environment in a negative,

[6] Ibid. 75-76.

cumulative, and, at least for some period of time, invisible way."[7] Because CPEs involve incremental changes that accumulate over time at a slow rate, degradation generally is imperceptible and is not recognized until a crisis has emerged. As a result, behavioral changes are not initiated, and ensuing environmental problems often are overlooked and neglected.

During the last twenty years, the cotton monoculture and irrigation practices in the Aral Sea region have created an environmental and economic crisis. As the diagram below depicts, the decline in the level of the Aral Sea due to water diversion for irrigation has led to severe environmental degradation with economic consequences.



Expansion of irrigation and cotton cultivation caused a significant reduction in the volume of the Aral Sea. The fourth largest inland sea until 1969, the Aral Sea is a closed limnological system; its level is determined by the balance among ground water and river inflow from the Amu Darya and Syr Darya Rivers, precipitation, and evaporation.

[7] Kobori and Glantz. 34.

The significant amount of water used for irrigation depleted river flow and ground water reservoirs. Increasing demand for water to irrigate cotton resulted in diversion from the Amu Darya and Syr Dayra, and a considerable decrease in the Aral Sea's depth as withdrawal rates exceeded recharge rates. "According to water management experts, the water resources of the Aral Sea basin had already reached full utilization in the early 1980s."[8]

Demand for water for irrigation is higher than optimal levels; in 1995, water demand for cotton in the Aral region was 7,500 to 12,500 cubic meters per hectare. Optimal irrigation standards for cotton range from 3,500 to 4,400 cubic meters per hectare.[9] Water consumption per irrigated hectare is excessive, "because specific soil and plant types and the actual consumption and mineralization of irrigation water are not fully taken into account." As mineralization occured, irrigation increased. "An increase in water mineralization by 0.1 grams per liter, is offset by applying an additional 1,000 cubic meters of water per hectare."[10] These statistics are indicative of withdrawal rates that exceed recharge capabilities.

Since 1960, land under irrigation increased 1.5 times in Uzbekistan and 1.7 times in Kazakhstan.[11] To support this expansion, water withdrawals by 1988 were 167 cubic kilometers or 124% of average annual water resources due to return flows that were used repeatedly downstream.[12] Withdrawal rates were so excessive that by 1970, the Syr Darya no longer supplied water to the Aral Sea. Presently, the Amu Darya supplies approximately 70% of the 122 cubic kilometers of water flowing into the Aral Sea each

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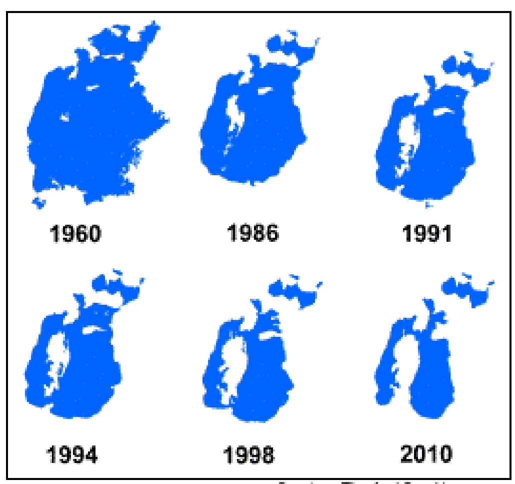
[8] Klozli. 3.
[9] Kasperson. 107.
[10] Kotlyakov. 9.
[11] Kasperson. 105.

year; however, an estimated 15 to 20 cubic kilometers is diverted annually for use in the Kara Kum Canal. Combined with a poorly constructed irrigation system, only an estimated 60% of the water withdrawn from the Sea's feeder rivers arrives at its destination; 40% is lost in the conveyance system.[13]

Increased demand for water for irrigation and to flush salt from older fields resulted in significant decreases in the Aral Sea and its eventual shrinkage. Prior to the 1960s, the Aral Sea's level fluctuated between 52 and 53 meters with a maximum depth of 69 meters. So much water was removed or prevented from flowing into the Sea that in 1987 the Sea split into a smaller (Maloe) and a larger (Bolshoe) sea. The larger one continues to grow drier annually although fed by inflow from the Amu Darya. Maintenance of the Bolshoe Sea at 37 meters above sea level requires annual inflows from the Amu Darya of 28 cubic kilometers. This is unlikely due to the economic factors driving water diversion. In contrast, maintenance of the Maloe Sea at a similar level, requires a minimum of three cubic kilometers of inflow from the Syr Darya annually. Due to a 12-mile long, 85 feet wide dike constructed between the two lakes at the town of Aralsk in 1997, the smaller sea's depth has increased from 115 feet to 125 feet. The dike has protected the smaller sea from further contamination by the larger sea to the south as the Aral's overall area, volume and sea level decreased.[14] The table on the following page



Courtesy The Aral Sea Homepage

[12] Stewart. 91.
[13] Stewart. 95.
[14] Matloff. 2.

depicts changes in the Aral Sea’s level from 1960 through 2000.

YEAR	AREA (km^2)	VOLUME (km^3)	SEA LEVEL (m)	SALINITY (g/l)
1960	~ 68.000	~1040	53	~10
1985	45713	468	41.5	~23
1986	43630	380	40.5	
1987	42650	354	40	
1988	41134	339	39.5	
1989	40680	320	39	~30
1990	38817	282	38.5	
1991	37159	248	38	
1992	36087	231	37.5	
1993	35654	248	37	
1994	35215	248	37	
1995	35374	248	37	
1996	31516	212	36	
1997	29632	190	35	
1998	28687	181	34.8	~45
2010	21058	~124	32.4	~70

Source: German Remote Sensing Data Center (DFD), German Aerospace Center (DLR). 22 February 1999. wysiwyg://32/http://www/dfd.dlr.de/app/land/aralsea/chronology.html

Soil Salinization and Pollution

A side effect of declining water level and irresponsible irrigation practices is the increasing salinity, pollution, and deteriorating water quality of the Sea. During the 1960s, the Aral Sea contained 10 billion metric tons of dissolved salts comprised of 56% sodium chloride, 26% magnesium sulfate, and 15% calcium sulfate.[15] By 1998, salinity had increased from 10 grams per liter to 45 grams per liter.[16] As the Sea shrank, these salts were deposited on the former bottom and transported during frequent dust storms to agricultural regions of the Amu Darya delta, along the Black Sea coast in Georgia, and along the artic shore in the former Soviet Union. Salinization of farmland resulted from

[15] Micklin. *Science*. 1172.

salty water used for irrigation, high evaporation rates, and the lack of precipitation necessary to leach out salts.

Declining water quality combined with salinization decreased soil fertility. Agricultural production decreased by 30% in Uzbekistan, 18% in Tadjikistan, and 20% in Kyrgestan.[17] Slight salinization can decrease cotton yields by 10% to 15%, moderate salinization by 30% to 40%, and severe salinization by 50% to 60%.[18] "In Uzbekistan, moderately and severely salinized soils constitute 60 percent of all irrigated land…and 60 to 70 percent in Kazakhstan."[19] Of 2.1 million hectares of salinized land in Uzbekistan, 300,000 are said to be 'severely affected,' 700,000 'moderately affected,' and 1.1 million 'only slightly affected.'"[20] As environmental degradation increases, per unit expenditures and agricultural costs have grown steadily while cotton production slowly falls. This phenomenon is largely a result of the decreased fertility of land under cultivation.

Salinization compelled farmers to increase the application of fertilizers, herbicides and pesticides in order to maintain and expand cotton yields. It also encouraged more irrigation to flush pesticides and salt residues from the land. Non-point source runoff was discharged into rivers through drainage canals and filtered through groundwater, polluting the Aral Sea and deteriorating the quality of water used for drinking and cooking. DDT content in soil in the Aral Sea basin ranges from two to seven times above the maximum permissible concentration.[21] Pesticides found in wells used for drinking water are in concentrations ranging from seven to 16 times the maximum permissible

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16 The Aral Sea Homepage.
17 Kasperson. 112.
18 Ibid. 112.
19 Ibid. 99.
20 Thurman. 7-8.
21 Kasperson. 100.

level and as high as 900 times in irrigation canals.[22] In addition, leaked and surplus water from over irrigation is creating bogs that displace pastureland and exacerbate salinization as water evaporates.

Besides harming agriculture and plant life, increased salinity of the Aral Sea caused aquatic productivity to decline and destroyed spawning grounds for fish. During the first ecosystem crisis occurring from 1971 to 1975, water salinity increased from 12% to 14%. As salinity surpassed 14%, most of the fresh and low brackish water species perished and the reproduction of the remaining fish was inhibited.[23] When salinity reached 33 grams per liter, spawning grounds were permanently eradicated. During the 1980s, the mean salinity of the Aral Sea increase to 23% at which time zoo- and photoplankton expired.

Salinization had an obvious direct impact on the commercial fishing industry and led to severe economic distress. Of the twenty indigenous fish species, only two remain in the Sea. The decline in annual fish catches over the years reflects the death of the Aral Sea and increasing economic hardship facing the region. During the 1950s, the annual catch of fish reached 44,000 metric tons. In 1960, 43,400 metric tons of fish were caught in the Sea. Ten years later, only 17,400 metric tons were caught, and by 1980, the yield was zero.[24] During the 1960s there were 61,000 people employed in one fish enterprise, eight fish plants, and 19 collective fish farms in Kazakhstan alone; presently, only 1,800 people work in the commercial fishing industry.[25] As a result, major fish canneries cut their workforces and began processing frozen fish imported from the oceans.

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[22] Aral Sea Health. 1.
[23] Kasperson. 96.
[24] Kobori. 47.
[25] Kasperson. 115.

Climatic Changes: Desertification

Recession of the Aral Sea also brought climatic changes that facilitated desertification and introduced dryer continental temperatures. The slight increase of 1.5 to 2.5 degrees Celsius in summer and winter temperatures increased recurring drought days by 300% and created new desert at the rate of 150,000 hectares annually. [26] Overall, the desert area has grown by 30%, consuming nearly 1.3 million hectares of agricultural land.[27] These events shortened the growing season inducing many farmers to switch from cotton production to rice which is an even more water intensive crop.

Destruction of Ecosystems

Pollution, salinization, and desertification destroyed the region's ecosystem. Prior to the 1960s, 20 fish species, 266 species of invertebrates, and 94 species of superior and inferior plants existed in the Aral Sea.[28] Today, only two species of fish remain and much plant life has died.

The decline in biodiversity was a consequence of the decimation of sensitive river deltas. Until the 1960s these areas possessed immeasurable ecological value, providing pastures for livestock, spawning grounds for commercial fish, reeds for use in the paper-making industry, and hunting and trapping areas. Today, these areas and uses either are non-existent or severely degraded. As soils dried out or became salinized or waterlogged, diminishing vegetation curtailed habitats for wildlife and migratory birds. Nine out of 27 animal species disappeared and four were listed as endangered in 1986. "Overall the diversity of mammals inhabiting the Aral Sea has decreased from 70 to 30 species and the number of bird species from 319 to 168. The disappearance of nesting sites for many

[26] Glazovsky. 97.
[27] Glantz. 67, The Aral Sea Project and Kobori..

bird species has led to the disappearance of 38 of 173 bird species nesting in the lower reaches of the Syr Darya."[29]

Human Health

The final side effect of the desiccation of the Aral Sea is the spread of human diseases. The quality of water used for drinking and cooking deteriorated as it became contaminated with salt, pesticides, heavy metals, and bacteria. Subsequently, infant mortality rates rose, life expectancy decreased by twenty years, and diseases such as cancer, gastro-intestinal problems, typhoid, congenital deformation, and viral hepatitis became prevalent. In Uzbekistan, from 1980 to 1987 the number of hospitalized people increased from 21.8 to 26.3 per 100 people.[30]

A population increase accompanied the deterioration in health, further exacerbating the already high demand for polluted water and spreading disease. Between 1950 and 1988, the population grew from 13.8 million to 33.2 million. By 1990, the population was 34 million.[31] Increasingly, government funds are being used to meet social needs associated with the population boom and to maintain the agro-economy; little money is left over to address environmental problems.

Economic Consequences

As is already obvious, environmental degradation is closely linked to economic losses in the Aral Sea basin. However, regional dependence on the cotton monoculture is so extreme that environmental issues and their economic consequences remain largely ignored. For example, in 1991, cotton "accounted for more than 65% of Uzbekistan's

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[28] Kasperson. 95-96.
[29] Ibid. 99.
[30] Pavilionis. 1.
[31] Ibid. 1.

gross output, consumed 60% of its resources, and employed 40% of the labor force. More than 70% of the arable land in the republic was devoted to cotton production."[32] In Kazakhstan, 20% of the labor force was employed in agriculture, and cotton constituted 33.9% of the country's output. [33] Desiccation of the environment led to 17.5% unemployment in Kazakhstan.[34]

Continued economic losses connected with the failure of industries dependent on the Aral Sea forced officials to develop the cotton monoculture even more extensively. Agricultural industries in the region reduced costs by almost completely externalizing the environmental damages; if these externalities were included, cotton production and output as well as irrigation would have significantly decreased. Since the market is unable to allocate resources efficiently in the face of externalities associated with cotton production, officials were and continue to be reluctant to engage in other economic development activities or to try to remedy costly environmental problems.

There are no accurate figures concerning damages associated with the Aral's desiccation. However, several studies have attempted to value the environmental ruin. A series of studies using the cost valuation method suggested that the minimum overall damage to the environment and the economy as a result of agricultural practices and irrigation in the Aral Sea region can be estimated by examining the cost of measures to eliminate the negative consequences. These estimates run as high as 37 billion rubles [US$1,291,899,441].[35]

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[32] Ibid. 6.
[33] Aral Sea Region Kyzylorda Oblast. 3.
[34] Ibid.
[35] Glazovskiy. *Soviet Geography*. 76.

A 1983 study concluded that the annual damages in the lower portion of the Amu Darya were "92.6 million rubles [US$3,233,240] with the following distribution: 42% agriculture, 31% fisheries, 13% hunting and trapping, 8% river and sea transport, and 6% living and working conditions. Another study estimates a figure of 1.5 to 2 billion rubles [US$52,374,302 to US$69,832,402] as the annual losses for the entire Aral Sea region."[36]

A 1990 study focused on restoring environmental quality to the region. It determined that between 25 and 30 billion rubles [US$872,905,028 and US$1,047,486,034] were needed to reconstruct the irrigation system, between 1.6 and 3 billion rubles [US$55,865,922 and $104,748,603] were needed to prevent polluted drainage water from entering rivers, approximately 10 billion rubles [US$349,162,011] would have to be allocated to introduce new plants and irrigation techniques, and 1 billion rubles [US$34,916,201] would be required to stabilize the sea floor. The study estimated that over 100 billion rubles [US$3,491,620,112] were required to improve sanitary, hygienic, and medical services, to create new jobs, and to alter the economy's structure.[37]

Another method focuses on calculating the socioeconomic losses from environmental pollution by determining the volume of unrealized gross production and gross and net profits or the loss in annual income. The Institute of Water Problems located in the USSR Academy of Sciences predicted in 1973 that annual gross income would decrease by 15 to 30 million rubles [US$523,743 and US$1,047,486] as a result of changes in the Aral Sea. This estimate does not consider the costs involved with

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[36] Micklin. *Science*. 1173.
[37] "Societal Recognition of the Aral Sea problem. 10.

mitigating further degradation or the economic losses resulting from deteriorating health and medical compensation

Steps to Remedy the Crisis

In order for the Aral Sea basin to recover environmentally and economically, the region must scale back cotton production replacing it with other less water intensive crops. Simultaneous development of the manufacturing sector is critical. Accomplishing this is difficult as both Kazakhstan and Uzbekistan lack well-developed infrastructures and skilled labor forces as well as capital to invest in the development of new industries. "Local political leaders gave expressed an interest in reducing their cotton acreage, but the cost in the short term would be great because cotton exports are the region's principle source of hard currency, netting the region $700 million annually in the early 1990s."[38] Efforts to date have focused on reversing the health and environmental damages caused by degradation of the Aral Sea without transforming the regional economy. Obviously, this strategy is less than successful since the economy and environment are inextricably linked.

Several approaches have been suggested as ways to ameliorate the crisis. One popular solution focuses on draining water from the Ob and Irtysh Rivers to the north and west of Siberia or diverting inflow from the Caspian Sea. This plan was cancelled when Gorbachev came to power in 1985. He considered this form of water transfer to be a poor and costly investment of scarce resources. The potential economic and ecological damage in the areas from which the water was diverted was too high. In addition, the necessary construction of a 1,600-mile long diversion canal, a politically complex proposal, is exorbitantly expensive. Although the plan would allow the cotton monoculture to continue, diverting water from other areas would simply encourage additional agricultural production and discourage water conservation. It is not politically or economically feasible or efficient.

A second proposal posits abandoning the cotton monoculture in order to stabilize and maintain or even increase water levels. In conjunction with this, proponents recommend the introduction of an enforceable property rights regime, water use fees, and more efficient irrigation methods. This option encounters strong resistance because of the extreme dependence on cotton production for the viability of the local economy and insufficient government revenue available for rebuilding irrigation systems. Over 180,000 kilometers of irrigation canals exist in Central Asia with less than 10% possessing linings to prevent seepage and reduce evaporation.[39] Any undertaking to reconstruct the canals would prove extraordinarily expensive. Prospects are limited further by "weak economies and growing populations [that] put national leaders under pressure to use any leftover water to grow more food. Before they can even think about the sea, officials say, the region must cope with the public health and economic calamities that have come in the wake of the Aral's depletion."[40] Moslem agrarian law complicates the development of an enforceable property and water rights regime in the region. The law does not recognize private property and considers water to be a gift from God that can neither belong to anyone or be sold. Rather, the law requires consumers to assist with the construction and maintenance of irrigation networks.[41] These religious

[38] Peterson. 116.
[39] Peterson. 116.
[40] Boudreau. 1.
[41] Klolzli. 10.

traditions must be negotiated before an enforceable water rights system can be implemented.

Other solutions focus on decreasing consumptive use of water from the Amu and Syr Darya Rivers in order to maintain a certain level of water inflow into the Sea. Simply decreasing water consumption is insufficient to preserve the Aral Sea at a level that has both ecological and economic value. A variation seeks to partition the sea with dikes in order to preserve low salinity conditions in a portion and allow the remainder to dry out.[42] These plans are not possible solutions since they require more surface inflow than is available.

Any long-term feasible solution must combine stabilization measures with changes in technology, the development of new industries, and an inflow of financial aid aimed at solving the economic and environmental problems of the region and preserving the Aral Sea. In order to address the water problem and obtain efficient water use, a combination of actions must be implemented. These include, at minimum, the five measures below.

1. Rebuilding older irrigation systems to reduce water losses by lining canals with concrete, plastic sheeting or clay and shortening the average length via consolidation.
2. Installing or improving collector-drainage facilities to remove excess ground water, and to prevent water logging and salinization. Most older irrigation canals in Central Asia lack engineered drainage networks and are choked with weeds.
3. Improving water application at the fields. In the early 1980s, 98% of irrigation in Central Asia was by surface methods where water flows from a canal directly

onto the fields and then through furrows to the crops. Central Asia needs to implement drip, sprinkling, or intersoil methods. However, use of alternative methods is limited by energy consumption, expense, suitability for some crops, and low levels of efficiency in desert environments.

4. Shifting from intensive water crops like cotton and rice, to crops that use less water, such as vegetables. This is limited by the existing economic, agricultural, and political infrastructure that supports cotton as the primary cash crop.
5. Improving water allocation and conservation via a pricing structure. Currently, water for irrigation is provided free which discourages conservation and leads to inefficiency and waste. However, any transition to water pricing must overcome the lack of water delivery measurement systems, outdated system of pricing, a failed economy, and religious laws. In addition, officials fear that rising water costs would make farms uncompetitive and hurt exports.

A long-term solution entails developing and constructing drinking and municipal water supply systems as well as sewage removal and treatment systems, prohibiting the use of pesticides, and introducing new irrigation technology that promotes water conservation. Doing so can increase irrigation efficiency to 80% from the current 67%. Automation of irrigation may increase efficiency further to 88% and save approximately 28 cubic kilometers of water annually.[43]

One program that aims to accomplish these goals is the World Bank's Water Supply, Sanitation, and Health Project that was initiated in 1997. It awarded Uzbekistan US$75 million in loans to improve the water supply and distribution by repairing

[42] Micklin. *Human Impact* Reader. 139.
[43] Glazovskiy. 81.

irrigation systems and developing local water supply and distribution systems as well as desalinization units. The program also sponsored a study on instituting water tariffs to encourage conservation.

Efforts to ameliorate environmental and economic degradation are in progress. However, results will be slow and many obstacles will need to be overcome.

Conclusion

The environment is an asset that developing nations frequently disregard when pursuing economic goals. Failure to manage natural resources responsibly and efficiently only results in further degradation and economic hardship as the Aral Sea case demonstrates. Ill-defined property rights and poor resource management policies combined with inaccurate economic valuation methods caused water scarcity and destroyed industries dependent upon the vitality of the Aral Sea. The continuance of these practices in conjunction with an excessive degree of dependence on the cotton monoculture ultimately worsens economic and environmental conditions. Ameliorating the situation requires severe transformations in the local economy, recognition of the effects of creeping environmental problems, and breaking the negative feedback loop.

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