THE ARAL SEA CRISIS: DESICCATION AND PERSPECTIVES ON RECOVERY

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Note: I wrote this article in 1997. Few issues have since changed. This copy is an original draft version. The figures are not included.

ABSTRACT

Desiccation of the Aral Sea is one of the world's most serious ecosystem catastrophes. The cause of the Sea's degradation is massive, consumptive withdrawals of water from the Amu and Syr Daryas. Irrigation accounts for 94 percent of all consumptive uses and is situated over 8.5 million hectares of land across the Aral basin. At current rates of water use, the Aral will progressively decline in size. By the year 2000, little more than a shallow brine pool will be all that remains of this former fourth largest lake in the world. The negative impacts of desiccation range from regional climate change to socioeconomic and health problems. Restoration of the Aral Sea basin is imperative if humans wish to live and function as they once did in a pre-degraded environment a mere 30 years ago. Interbasin transfers and water management practices are not successful methods for ameliorating the problems of desiccation. Generally, restoration has not been successful in the region. A number of institutional and philosophical barriers which resist restoration are discussed. Perhaps the reshaping of these barriers will lead to the long term development of alternative restoration practices.

INTRODUCTION

The Aral Sea has been described as one of the world's most serious environmental and human tragedies (Micklin 1992, 274). Once the fourth largest lake on the planet, the Aral Sea is rapidly becoming a water-starved, brackish puddle. Since 1960, the Sea has lost 73 percent of its water volume and has decreased in area by more than 50 percent (Micklin 1993, 14). Despite such alarming basin-wide desiccation, little in the way of restoration has been attempted. To date, the few attempts at restoration have been overwhelmed by volatile political and economic conditions within the Sea's basin. As such, no measurable degree of ecosystem rejuvenation has not been reached. This paper will have two major focusses: Aral Sea desiccation and restoration. A discussion of direct cause and consequences of Sea desiccation and an explanation of proposed and practiced Sea restoration projects will be presented. The final section of this paper will argue that there has been little success with regard to the Aral Sea's restoration. It will; thus, discuss four institutional and philosophical reasons as to why restoration in the Aral Sea basin has not developed. At issue are the approaches to water resource rationing.

DESICCATION

The Aral Sea is literally "drying out". Massive consumptive withdrawals of water from the Amu Darya and Syr Darya Rivers are depriving the Aral Sea of its natural intake of water. Fossil records indicate that the Aral Sea has had repeated major surface level fluctuations during the past 10,000 years (Smith 1994, 146). Major recessions and advances of the Sea were a response to gradual climatic swings. Currently, the Sea is experiencing a rapid recession and major volume reduction, which cannot be attributed to the slow progression of climatic change. Consequently, the natural and social environments along the Sea's coasts and tributaries, including the highly populated deltaic areas, are being degraded (Murzayev 1992, 296). This rapid fall in sea level began in 1960, is continuing, and when it will end is, in fact, unclear. The following section will provide insight into the physical setting of the Sea and causes and consequences of regional desiccation.

Physical Setting

The Aral Sea is a shallow basin, saline lake located in southeastern Asia. The Sea and its tributaries were once situated entirely within the borders of the former Union of Soviet Socialist Republics. However, much like the Sea is changing, the cultural setting is, likewise, experiencing turmoil. The Aral Sea basin is occupied by the newly independent republics of Kazakhstan, Uzbekistan, Turkmenistan, Kyrgyzstan, and Tajikistan. Climatically, the entire basin lies within a desertic environment. The Amu Darya and Syr Darya flow through the Kyzylkum and Karakum Deserts (see Figure I). The climates along the Sea's tributaries are dependent solely upon the River for moisture (Aladin and Potts 1992, 70). The Sea's shores are interrupted in the North by the Syr Darya delta and in the South by the Amu Darya delta. The deltas, seashores, and river edges exert an influence on and give rise to a microclimate which is a more humid landscape than in the surrounding desert. These are the regions which have been occupied by humans for thousands of years -- reliant upon the water to sustain life (Kes and Klyukanova 1990, 603). The river and its settlers have remained in dynamic equilibrium until recently. Previous development did not reduce river spill into the Aral, because the regions occupied were within the river valley and deltas -- areas with an abundance of moisture (Precoda 1991, 110). Today, the Aral is "out of balance". Its morphology, size, and shape are being completely reworked.

Causes

Technological advances and large-scale water withdrawals are the culprits of basin-wide desiccation. The Aral Sea is a terminal lake. It is dependant upon river and groundwater in flow and precipitation in order to maintain surface levels. The Sea's only "out-take" is not by flow, but rather from evaporation (Micklin 1988, 1170). As water is withdrawn from the Syr and Amu Daryas, mostly for irrigation purposes, stream and groundwater inflows are reduced, such that lake recharge is impeded. Consequently, the system is out of balance and evaporation occurs more rapidly than recharge, resulting in drastic surface and volume decreases.

In the 1950s and 1960s a massive expansion of irrigation took place in the Sea's basin. The USSR wanted to: 1) quadruple raw cotton production, 2) increase the production of vegetables and fruits, 3) supply the central Asian republics with rice and export that much again, and 4) subsequently provide employment for all of the local population (Glazovskiy 1991, 74). In order to meet these lofty goals, large quantities of water had to be diverted from the area's principle rivers, the Amu and Syr. By 1960, over 5 million hectares of land were under irrigation. In 1980, irrigation in the Aral Sea basin jumped to 6.5 million hectares, and in 1990, an estimated 8.5 million hectares continued to increase consumptive withdrawals (Micklin 1988 and 1993). As a result of water diversion for irrigation, the volume of river discharge has steadily dropped. Before 1960, an average of 56 km^3/year of water entered the Aral, out of a total 120 km^3/year of river water forming in source regions in the basin. By 1975, as irrigation withdrawals increased, the flow into the Sea was approximately 9 km^3/year (Glazovskiy 1991). Since the 1970s, the Amu and Syr Daryas have witnessed no reprieve in water consumption. In fact, in some years, there has been virtually no inflow of water into the Sea (Kotlyakov 1991, 6).

Certainly, agricultural production has increased over the years; thus, the goals of former Soviet central planners and, today, independent republic planners have been reached. Uzbekistan, the largest consumer of water, now irrigates 4 million hectares of crops alone (Lubin 1989, 630). Uzbekistan, as well as the other four republics, produces large quantities of water-consuming cotton and rice -- but at what cost?

Consequences

The anthropogenic desertification of the Aral Sea is severe. Its natural habitat, local climate, and regional hydrology have all been affected. The boom or bust economic resource strategy places on the region is now collapsing, leaving the local populations mired in poverty. What economic prosperity that existed is drying up, much as is the region's primary resource: water. Table I represents the degrading hydrologic parameters of the Aral Sea. Note that the 1993 and 2000 parameters are divided into two parts, as the Sea in 1990 completely divided into two water bodies -- a small sea in the North and a larger sea in the South.

Year	Sea Level (meters)	Sea Area (1000 sq km)	Sea Volume (cubic km)
1960	53.30	67.9	1090
1965	52.50	63.9	1030
1970	51.60	60.4	970
1975	49.40	57.2	840
1980	46.20	52.4	670
1985	42.00	44.4	470
1993 Large Sea	36.89	30.9	279
1993 Small Sea	39.91	2.6	21
2000 Large Sea	32.89	21.0	159
2000 Small Sea	40.97	3.1	24

Sources: Adapted from Micklin (1993) and Kotlyakov (1991).

TABLE I

Certainly, the consequence of large water withdrawals from the Aral Sea's basin are not entirely confined to desiccation. Desiccation perpetuates additional ecological and sociological degradation. As desiccation increases, so do the detrimental impacts on the ecosystem. As the ecological and sociological systems worsen, likewise, desiccation worsens, thus, establishing a linked, concomitant relationship. The following discussion comments upon the major consequences and changes of the ecological complex, inexorably linked to the shrinking Sea.

<u>Climatic Change</u> -- Water is the most important natural resource in southeastern Asia, because of the area's arid climate. Climatic changes spurred by anthropogenic desiccation are occurring. Reciprocally, changes in the climatic patterns (principally precipitation) greatly decrease river runoff and progressively increase desiccation (Smith 1994, 160). Precipitation in the region is slightly decreasing, as maximum average daily temperatures are increasing (Precoda 1991, 111).

Wind Erosion -- Wind erosion is now common throughout the Aral Sea basin, because the Sea no longer acts as a barrier against the wind's drying effects. Salt deposits from the drying Sea in many places coat the once productive agricultural lands. More than 1 million hectares of once productive land are covered with windblown salts (Precoda 1991, 111).

Groundwater -- As the Sea dries, the groundwater levels along riparian and coastal zones drop. In some areas, the drop is as much as seven to eight meters. Riparian vegetation in these zones dies and leaves large patches of bare, sandy soil on the order of 25 to 100 km wide bands (Precoda 1991, 112).

Salinizaton -- The average salinity in 1960 was 10 grams/liter in the Aral Sea. In 1993, the salinity level had risen to an average of 35 grams/liter (Aladin et.al. 1993, 22). Since 1960, the native flora and fauna species have been altered, due to increased levels of salinity, as the result of water abstraction from the Syr and Amu river basins. As water levels drop, salt concentrations increase. These changes to the aquatic environment have induced such adverse effects on the flora and fauna, many species have disappeared or are in a depressed condition (Aladin et al. 1993, 25). Additionally, as the water becomes more saline, freshwater flora and fauna are quickly replaced by saline-tolerant species.

Irrigated lands are, likewise effected by increasing levels of salinity. Approximately 40 percent of all irrigated land is strongly salinated in the Aral Sea basin (Lubin 1989, 630). Secondary salinization, due to excess irrigation, is rendering much agricultural land unusable. The situation has culminated in some areas along the Amu and Syr rivers, such that the annual rate of land loss due to salinization now exceeds the rate of development of new areas for agricultural production (Precoda 1991, 113).

Societal Effects -- With a population greater than 32 million occupying 1.5 million km of land in the Aral Sea basin, profound societal changes are to be expected as desertification increases (Smith 1994, 143). It is ironic that rapid desertification is occurring only as a response to anthropogenic influences. As this reciprocal relationship unfolds, a catastrophic drop in both basin and living standards is simultaneously occurring. Economically, the living standard has dropped, as people are unemployed. Many of the people in the Aral basin were employed either directly or indirectly by Sea- or River-dependant jobs. As more agricultural land is taken out of production, the poor socioeconomic conditions will only increase. Further, the quality of life has been deteriorating, due to a variety of severe health problems: "respiratory afflictions and possibly cancer from the blowing dust and salt; intestinal disorders from poor quality of drinking water; and, diseases, such as cholera, hepatitis, and typhoid" (Micklin 1993, 17). Infant mortality rates are greater than 100 percent in some regions and morbidity rates across the entire region are increasing (Micklin 1993, 17). Restoring the Aral Sea is of minor importance, compared to the radical improvements needed in public health and the socioeconomic situation.

Figure III is useful, in that it summarizes causes and consequences of the Aral Sea's plight. Note the reciprocity and linkages within the system. The ultimate cause of the Sea's desiccation is an increase in water demand, while the major consequence is a decline in area and ecosystem productivity.

RESTORATION

The Aral Sea basin is in a state of ecological disaster. Natural ecosystem linkages have been so profoundly destroyed that the human population can no longer live and function as it once did. If ecosystem degradation is allowed to continue unhampered, an irreversible catastrophe is imminent. The urgency of the situation has brought about an international focus on restoring the Sea. Ideally, any attempt at restoration will incorporate the following rational characteristics: 1) replenishment of the Aral Sea's waters, 2) restoration of a stable ecosystem, 3) decreased salt and dust export by blowing, and 4) improved local microclimates (Government Commission on the Development of Measures for Restoring Ecological Equilibrium in the Aral Region 1992, 287). The following discussion considers proposed and established methods for solving the Aral crisis.

Interbasin Transfers

In a joint declaration on mutual problems in the Aral Sea, four Soviet republics announced that the only way to avoid regional ecological catastrophe was to turn to Interbasin Transfers (IBT). If the Aral is to be saved, more water has to be available to the system (Micklin 1990, 93). Several such transfers have been explored. One of the earlier IBT's suggested that some of the Caspian waters be diverted into the Aral Sea. It has been asserted that the Caspian Sea receives a surplus of precipitation caused by an increase in evaporation in regions to the West and South of the basin (Glazovskiy 1991, 83). This project, however, is unsound. Before such drastic acts are taken, proof must be brought forth which clearly determines that the Caspian basin will not suffer negative consequences. One of the other IBT's which has been proposed suggests that part of the Volga's runoff be diverted into the Aral Sea by way of dike and canal. Another project planned for a diversion of some runoff of Siberian rivers into the Sea. In all cases, the potential consequences of creating an environmental catastrophe elsewhere in order to ameliorate an existing problem are high (Glazovskiy 1991, 84). Further, such transfers would require an enormous amount of capital and land acquisition, with little potential to solve the Sea's problems. Long-term solutions must rely upon a reduction of the region's water uses.

Precipitation Enhancement Measures

Hydrometeorologists have proposed that an increase in river discharge by moisture enhancement measures would lead to greater intakes of water into the Aral Sea. Two projects have been suggested. The first postulates that an injection of condensation nuclei into the lower troposphere over the Aral Sea basin would not only be expensive, but the social ramification of depriving precipitation in other areas has not been evaluated. The second project asserts that the construction of large reservoirs roughly 70,000 km^2 in the Ob and Yenisey basins would alter the thermal regime of the area and increase evaporation. As a result of an increase in moisture transfer to southeastern Asia, the volume of water carried into the Aral basin would increase. The construction of huge reservoirs in west Siberia is objectionable, because enormous areas would be flooded, causing productive lands for both natural and human habitats to be lost. Indeed, the very possibility of directing and transferring moisture to the Aral basin is suspect (Glazovskiy 1991, 84).

Water Management

Currently, the only attempt at restoration in practice in the Aral Sea basin is one which incorporates water management. The management program, which began in 1980, sought to gain more efficient use of irrigation waters. Irrigation in 1980 accounted for 91 percent of withdrawals and 94 percent of consumptive use. Naturally, irrigation was the target for management (Micklin 1988, 1171). Between 1980 and 1987, irrigation ditches were lined, return flows for excess water were built, and low yield, waterlogged fields were removed from irrigation. Generally, the efficiency of irrigation improved. Average withdrawals lowered from 18,500 to 13,700 m^3/ha (Micklin 1988, 1171). Today, the need to open more land to agriculture at increasing distances from the River's edges has resulted in no net water recovery for irrigation improvements. As the water was saved, it simply was diverted to new agricultural sites. Additionally, what control the USSR projected on irrigation efficiency was abolished when the five republics gained their independence. Economic and political conditions of the republics have since put more demands at lower efficiency on the Aral basin waters.

Water management holds more promise for Aral Sea recovery than do IBTs or precipitation enhancement techniques. IBTs and precipitation enhancement are, at best, short term answers to long-term problems. A general sense of euphoria will overtake the people of the region, because the water in the Aral will increase. However, as the water rises, more land will eventually be irrigated, and the potential for an ecological crisis in two basins now exists. Water management techniques deal with the reality that desiccation can only be ameliorated by a reduction in use.

Perspectives for the Future of Restoration

Ecosystem conditions in the Sea's basins are worsening (Micklin 1991, 96). New system-wide integrative approaches to restoration must be realized, in order that deep-rooted barriers to change be removed. The future of restoration hinges on the removal of the following four barriers.

The grassroots belief instilled by the former USSR into the people of the Aral region (that humans must transform nature) must change. On the surface, clearly the cause of the Aral Sea's degradation is consumptive water uses. However, the source of the problem runs much deeper and is obscured by former Soviet politics. One of the central premises of Soviet central planning was "man over nature". The transformation of nature was the ultimate demonstration that humans, specifically Russians, were masters of their environment. The fundamental reason for the Aral Sea tragedy is found in the discrepancy between the existing production structure of the economy and the condition of the ecosystem. Simply, Soviet planners implemented incorrect economic development strategies, which originated more than 30 years ago (Micklin 1992, 269). This basic philosophy of humans over nature is strong in the people of the Aral Sea; thus, change will come slowly.

The level of economic development poses a barrier to restoration. In order to save the Sea, a comprehensive concept of escaping from the area's economic and social crisis must be developed. The present situation is occurring because of ignorance in the past, where the administrative system sought to harness nature for short-term economic relief, in lieu of long-term economic development. The Aral tragedy is the inevitable result of a deep crisis in the regional economy.

The region must overcome the barrier of disorganization. Ironically, there is a need for central planning. The republics of the region must seek a high degree of cooperation. The recent 1994 agreement between the independent republics to pledge one percent of their budgets into a central fund to help restore the Sea is a step in the right direction (Pearce 1994, 10 and Editor 1994, 206).

Finally, restoration itself is a barrier. By recognizing that restoration is impossible, restoration can begin. To restore the Sea to its former "natural" conditions is an unattainable goal. Even to restore it to its condition of 30 years ago is not achievable. Alternative management plans which call for functional rejuvenation, rather than complete restoration, are needed. Perhaps management plans built upon water pricing and resource rationing are among the best approaches to achieving functional rejuvenation. Preservation and partial restoration of the Aral Sea and its tributaries are important. Such small-scale efforts would eventually build to large-scale efforts, consequently benefitting the natural environment and the local economy as water levels in the Aral begin to once again rise.

CONCLUSION

The Aral Sea does not exist in isolation. Rather, it is a complex, highly integrated ecological system. Water withdrawals on the Amu Darya may have profound effects on the health of populations living on the Syr Darya's delta. Certainly, the Aral's catastrophe currently unfolding will not be limited only to the Sea, but will have disastrous consequences within the entire basin. The primary cause of desiccation is irrigation withdrawals along the Amu and Syr Daryas. At current rates of desiccation, by the year 2000 the Sea may be little more than a brine pool. The consequences of water withdrawals are far reaching. Climate, groundwater, natural biota, and social conditions may be negatively modified. Such negative impacts can only be ameliorated through restoration. However, restoration attempts in the Aral Sea are not working. Deep-rooted philosophical beliefs exist in many of the people of the Aral basin. Restoration will never be successful unless plans are developed to replace or reshape these barriers. The Aral Sea is a resource which needs to be rationed. The alternative is no resource at all.

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