



Rehabilitation of the 'Small' Aral Sea

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Introduction

The Aral Sea, formerly the fourth largest inland sea in the world and home to a thriving fishing industry, has been shrinking for the last 40 years (Figure 1). The two great rivers that once fed the sea, the Amu Darya in the south and the Syr Darya in the north were moved from their beds in the late 1950's. To meet the Soviet goal of self-sufficiency, the waters were diverted into canals to irrigate agricultural crops. The water from both rivers that reaches the sea has been reduced by 78%, causing the surface area of the sea to decline by half, the volume to decline by nearly 2/3, and the salinity to more than double (Saiko, 1998). Many local people and scientists of the region suggest that it is possible, and desirable to bring the sea level back to its pre-1960 levels. There are many difficulties in attaining that goal, the largest of which is that it may cost a major part of the regions' agricultural economy. Therefore, despite great will and intention, little has been done, or reported to have been done, to reduce the amount of water diverted from the rivers for irrigation of agriculture.



Figure 1. A view of the Aral Sea, from north to south.

History of the Region

The Aral watershed basin region is comprised of five republics of the former Soviet Union: Turkmenistan, Uzbekistan, Tajikistan, Kyrgyzstan, and Kazakhstan (Figure 2). It is an arid region and the traditional peoples (Figure 3) were nomads that cultivated the fertile deltas of the great rivers which historically were called the Oxus (Amu) and Jaxartes (Syr). They traded raw cotton, silk, and dried fruit with the Europeans and Russians who would venture into the deserts. Russia, Britain, and Asia fought to rule the region but the Kirghiz and Mongols kept both the British and Russians from colonizing Central Asia for centuries. Towards the end of the nineteenth century, however, the Russian Empire conquered the area. They collectivized the small farming operations and built canals for irrigation (Wood 1876).

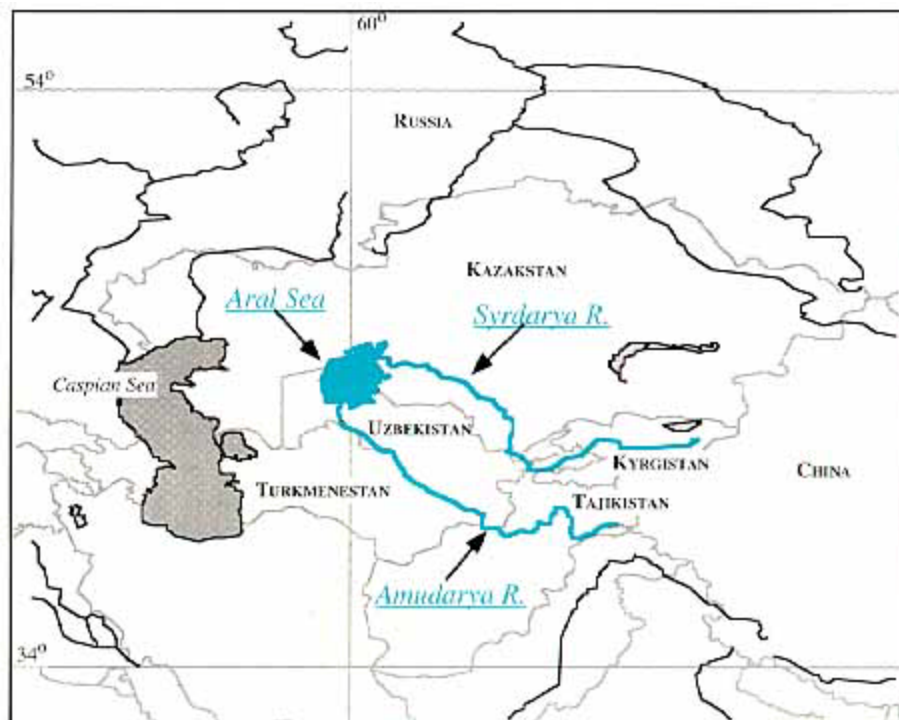


Figure 2. www.ce.utexas.edu/centers/crwr/watermarks/fall95/articleone.html



Figure 3. Traditional family and "Yulta" in Kazakhstan (photo: Yukihiro Morimoto)
<<http://rosa.envi.osakafu-u.ac.jp/~yuki/aral.html>>

Expansive and exploiting conduct were common Russian and European tendencies of the time regarding colonies and their resources. Major Herbert Wood (1876) of the Royal Engineers of Russia reported his observations and opinions of the region in his book, *The Shores of Lake Aral*. He reported that in 1874 the Syr Darya had poor navigation qualities that were degraded further by the opening of a large irrigation canal. He recommended that the most sensible option regarding the Syr Darya would be to undertake an "elaborate and expensive engineering project" to completely abandon the river as a navigation channel and use its entire volume for irrigation.

In yet another chapter, Wood (1876) wrote of the amelioration of certain sterile, arid country, such as that near the headwaters of rivers, by use of reservoirs. In these areas of the region, he reported, water was so scarce that the little vegetation that did grow was too bitter even for a camel to eat. Holding back the spring floods from the snowmelt of the Hindu Kush, Pamir, and Tien Shan Mountains was a good use of waters that were considered to be wasted in the sands of the desert or the lake (Aral Sea). When the ecology of the region is considered, it is clear that the waters were not wasted in the desert or the sea. At the time that the momentum for canal building and irrigated agriculture began, however, this may have been a reasonable assumption.

After the 1917 Bolshevik Revolution the Soviet government began their quest for independence from the outside world. In the 1950's Nikita Khrushchev was politically active and an advocate of the virgin lands scheme, which sought new lands for cultivation. Khrushchev regarded Central Asia as if it was an extension of the Ukraine, the breadbasket of the USSR. The climate of Central Asia, however, is continental. The region is on the same latitude as the state of Maine (US), and it is arid, with hot summers and cold winters.

It was political motivation that drove Khrushchev to push grain production in Central Asia. When salinization and water logging of the land and the arid climate proved too hostile for profitable grain production, cotton became the USSR's "White Gold"(Zonn, 1994). Following the Civil War, the new Soviet regime rearranged the organization of water resources. Regional boundaries were set according to the water-related administrative units set up by water planners in Moscow rather than by watershed basins.

Beginning in the mid 1920's and even more so in the 1950's, irrigation projects in Central Asia took on massive proportions (McKinney, 1996). Between 1950 and the late 1980's, the land area devoted to irrigated agricultural production increased from 5.4 million hectares to 9.4 million hectares (Saiko, 1998). Due to loss of soil fertility, increase in water salinity, salinization of soils, and other poor management methods, cotton production itself began to decrease in 1980 even though the land devoted to production continued to increase (Saiko, 1998).

The Kara Kum Canal, at 1100 km in length, diverts almost a third of the flow of the Amu Darya through the Turkmenistan desert (Bedford, 1996). The irrigation system in Central Asia had grown to include 52,800 km of canals, 390 reservoirs, and 230 dams by 1987 (Figure 4) (Saiko, 1995). Turkmenistan built an additional 300 km on the Kara Kum Canal in 1993 and planned to build 3 new reservoirs to divert another 6 km³ of the Amu Darya with the new projects (Saiko, 1995).

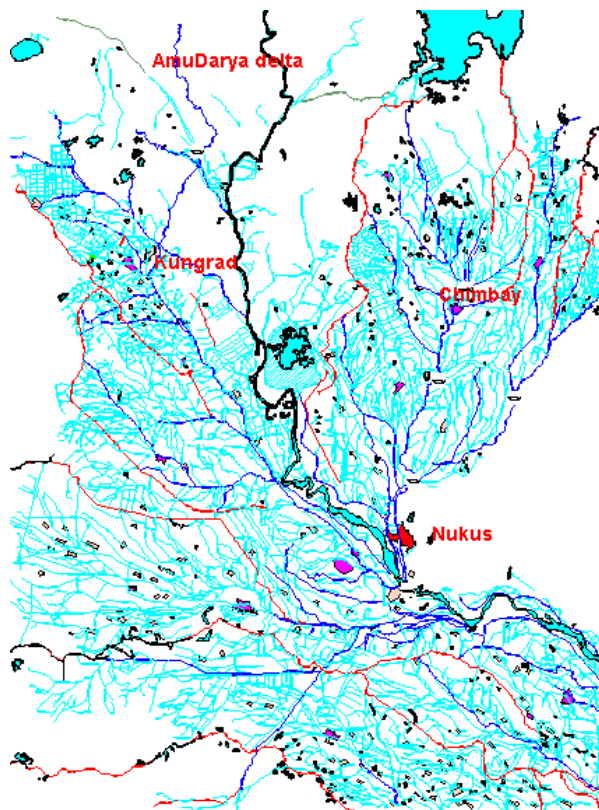


Figure 4. AmuDarya delta digital irrigation and drainage network (Philip Micklin)
<http://giserv.karelia.ru/arial/gif/irrigcut.gif>

History of the Sea

Wood (1876) writes extensively about the changes in hydrology that the Aral Sea region has experienced over the past centuries. He suggests that the Caspian and Aral Seas were once one large sea and that the Aral Sea level was already receding at the time he observed the region, the late 1800's. He further suggests that the Amu Darya and Syr Darya have changed their course of flow naturally, and by human intervention more than once in the past few centuries. This indicates that extensive irrigation has taken place in the region in the past. Following this line of reasoning, one might suspect that past diversion of waters for irrigation, which is written of in the sixteenth century Russian Great Map, may have led to consequent salinization and degradation of the land as it has in more recent history. It is probable that the abandonment of diversion efforts and a shift to nomadic society might have allowed the recovery of both rivers and sea.

The concept of canals and irrigation was not likely a new one in the region when the USSR ruled it. It may be that the sea was very slowly receding due to centuries past interventions or even natural causes. If the Caspian and the Aral were once the same sea it is unlikely that humans were responsible for their separation. What is most noteworthy in the case of the Aral Seas' most recent change is that rate at which it happened. The status of the Aral Sea in ancient history can be debated, however the shores of the sea in recent history, the flora and fauna that the local residents can remember is arguably the most valuable. Climate and vegetation that were present only forty years ago are what made the region habitable. Also a concern is the long lasting effects of modern agricultural chemicals. The Soviet Union's campaign to turn the products of the region into currency led to a very rapid degradation of the region (Glantz, 1998).

Prior to the building of dams, reservoirs and canals for irrigation, the volume of river water that reached the Aral Sea was a bit more than 50 km^3 per year. That was just enough water, in combination with about 9 km^3 of precipitation per year to keep the Aral Sea water level fairly constant (Aladin et al., 1993). Prior to the 1950's the sea had a volume of 1090 km^3 , a surface area of $68,000 \text{ km}^2$, and an average sea level of 52 m AMSL (above mean sea level) (Aladin et al., 1993, McKinney, 1996). Central Asia is arid, resulting in high evaporative losses from the Aral Sea's large surface area. To maintain a volume of around 1000 km^3 despite high evaporative losses required the entire volume of river inflow and precipitation.

Impact

Large scale agriculture, poor irrigation methods, and over-use of chemicals led to a host of environmental problems. Some of the more apparent are the desiccation of the Aral and its delta wetlands, wind transportation of salts and chemicals from the dry sea bed, local climate changes, and loss of commercially viable fish species (Bedford, 1996, Glantz, 1998). The ecology of the sea and surrounding lands were degraded, and the health and socio-economic well being of the people of the region were impacted.

Due to salinization, waterlogging and exhaustion of soil, the amount of land devoted to irrigated agriculture continues to rise. By 1995, 2.1 million ha of irrigated lands were salinized and

500,000 ha waterlogged (Mainguet, 1997). As lands that are no longer arable are abandoned, new canals are built into virgin lands to maintain agricultural production.

Irrigated agriculture and especially the production of cotton, have led to the over-use of agricultural chemicals. The poor value of the soils in the region required the use of fertilizers at a higher level than other agricultural areas in the USSR. In 1975 the average amount of fertilizers used in Central Asia was well over 150 kg/ha. In 1993 Uzbekistan still used about 150 kg/ha, Tajikistan used 97 kg/ ha, and 20 kg/ ha was used in Kyrgyzstan compared to an average of 29 kg/ha in the Russian Federation. The production of cotton also requires defoliant which were used extensively in Central Asia (Saiko, 1998). The most widely used defoliant, butifos, is associated to a high proportion of school-age children in rural Uzbekistan with nervous system and mental disorders (Tsukatani, 1998).

Massive diversion of river water for increased agriculture needs reduced the river flow into the Aral from over 50 km³ to 43.3 km³ between 1960 and 1970. More water than what was required for irrigation was diverted to compensate for infiltration losses due to poor canal construction. Older canals are little more than ditches dug in the sand. According to Saiko (1995), 18% of the 13.5 km³ /yr. of water removed from the Amu Darya is lost to evaporation and infiltration through the Kar Kum Canal. Between 1971 and 1980 the flow that reached the Aral Sea was reduced even further to 16.7 km³. The reported flow from 1981 to 1983 was a mere 2 km³ (Aladin et al., 1995).

The marked reduction in flow caused the level of the sea to fall drastically. By 1989-1990 the level was so reduced that the sea was divided into two parts: the large southern, and small northern, Aral (Aladin et al., 1995). The total surface area of the sea shrunk to 32,000 km² and volume to 310 km³ by 1994. The receding seashore left a bed of drying toxic sediments from the pesticides, fertilizers and defoliant used in agricultural production which is prone to wind borne dispersal. According to Saiko (1998), dust storms originating in the dried seabed were observed from space as early as 1975. In 1981, storms affecting up to a 300km radius, were observed on as many as 90 days per year. These storms also remove 43 million tons of sediment from the seabed every year (Saiko, 1998, Ellis 1990).

The region contained a wealth of wildlife prior to 1970, the sea had 24 species of fish including sturgeon, sudak (pike-perch), barbel, sazan (carp), bream and volba (Caspian roach) and many invertebrate lake species. Many mammals roamed the desert and oasis such as the wolf, jackal, fox, corsac fox (*Vulpes corsac*), reed cat, wild boar and deer while above them flew 173 species of birds and waterfowl including the egret (Calder, 1995). The famous reeds and the tugai brushwood in the delta region and surrounding the sea have been decimated as the shore receded (Saiko, 1998). With the loss of the vegetation, the wildlife that depended on them disappeared.

The impact on human health is numbing. Decades of poor drinking water and exposure to agricultural chemicals have left the people of Central Asia, especially the women and children, diseased (Saiko, 1998). Close to 100% of Karakalpakstan's women and children have anemia (Ataniyazova, 1998). Remarkable increases in respiratory and eye diseases are caused by the airborne salts and other particulates (Ellis, 1990). An increase in esophageal cancers are directly attributable to water contamination. Other health effects include high infant mortality (82 of

1000 births in Uzbekistan), gastro-intestinal problems, viral hepatitis, contaminated breastmilk and a reduction of life expectancy of 20 years compared to the Commonwealth of Independent States (Glantz, 1998).

There have also been increased rates of cancer of the throat, liver, stomach, and leukemia. The causes of these diseases are more difficult to assign, however, agricultural chemicals are strongly indicated by health professionals in the region (Ataniyazova, 1998). As late as 1990, DDT continued to be used in Central Asia, as well as a defoliant called butifos which makes cotton easier to pick (Ellis, 1990). Both chemicals are banned in the US. Butifos was banned by the USSR in 1983 and its manufacture was banned in 1987 due to its negative effects (Tsukatani, 1998). Despite the high infant mortality rate, and poor health of the region, the population of Central Asia continues to increase by 2.6-3.2%, creating more pressure on an already overburdened ecosystem (Mainguet, 1997, Glantz, 1998).

The fishing industry collapsed as the sea became too saline to support commercially viable fish. The fishing village of Aralsk, Kazakhstan now stands deserted, 18 km from the sea, its fishing boats marooned on the hot desert sand (Mainguet, 1997). 1958 saw the peak fish catch from the Aral Sea of 24,000 tons. The fishing industry of the Aral Sea once employed over 60,000 people. There were many species of commercially viable fish including pike, perch and bream, now there are none. From the time of the collapse of the fisheries in 1980, till the early 1990's, fish were shipped from the Arctic, Baltic and Pacific for processing in the city of Muynak which is now far from the sea's shore (Ellis, 1990, Saiko, 1998).

The impact on the social structure of the region is deep and difficult. One aspect concerns the fact that the economy of Central Asia is dependent on cotton to export and sell for food. Since the fall of the Soviet Union, the newly independent states began to produce more grains to meet the local food demand. There is difficulty, however, in growing a crop in the salinized, waterlogged soils that resulted from years of poor farming methods. Without the subsidies that the Soviet Union provided in the past, they must pay hard currency for food, which requires maintaining the current levels of cotton production, their main export (Saiko, 1998). In other words, self sustainability in cotton was acquired at the expense of self sustainability in food (Saiko, 1998). According to Saiko (1998) most people in Central Asia are living below the poverty line; for example, 78.5% to 93% of a Karakalpakstani's monthly income is spent on food.

Realities of Rehabilitation

Beginning with the perestoyka period in the late 1980's the USSR's and the world's attention was finally focused on the crisis in the Aral Sea region. The Aral Sea Scientific and Coordinating Center was created in 1988 within the Institute of Geography of the USSR Academy of Sciences (Saiko, 1995). In 1990 the United Nations Environment Program (UNEP)/USSR International Project "Assistance in the preparation for the Plan of Action for rehabilitation of the Aral Sea" was sponsored by UNEP and implemented by the Center for International Projects. Scientists analyzed the data and made recommendations for further progress. And in 1990 the Fund of Global Infrastructure of Japan was created to lend support to the efforts (Saiko, 1995).

Since the fall of the Soviet Union, many international conferences and symposiums were held to discuss the possibilities for saving the Aral. Just before the disintegration of the USSR, the locally infamous Siberian water transfer project was discussed again despite discarding the project in 1986 (Saiko, 1995). Another plan included blowing up the glaciers of the Pamir and Tien Shan mountains (Tsukatani, 1998). Such proposals would not have been feasible and may have created new areas of ecological disaster. The Central Asian countries have made agreements concerning the Aral. In 1992 the five independent countries of the region signed a document to insure delivery of water to the sea and its deltas and in 1993 they signed an agreement on the Aral Sea crisis (Calder, 1995, Bedford, 1996). In 1994, the countries pledged to give one percent of their GNPs to the Aral Sea Fund, they also agreed to reduce their use of river water for irrigation. However, due to the poor economic state of the countries, they have had trouble upholding their agreement. It was reported in late 1994 that no had so far reached the Aral Sea Fund (Calder, 1995). The implementation of water allocations is managed by a body called a BVO (a Russian acronym for River Basin Commission) there is one for the Syr Darya and one for the Amu Darya. Unfortunately, due to lack of funds and legal standing the BVO's have not the ability nor the authority to manage the water allocations of the region therefore it is generally left to the individual states (Bedford, 1996). The cooperation between the five Central Asian has been considered an "illusion of unity" (Olcott in Bedford, 1996).

Unfortunately, after more than ten years of planning and allocating funds by the five independent countries and international organizations, not much has been done to increase the Central Asian standard of living or rehabilitate the sea (Ataniyazova, 1998). Saiko (1998) reports that US \$200 million has been spent on some 20 projects with successful developments (although he does not cite examples). He also admits that some projects are less successful due to a lack of attention given to local needs and concerns, and that few projects include the support of local non-governmental organizations (Saiko, 1998). Ataniyazova (1998) claims that the effect of projects implemented by international organizations is minimal. She further asserts that organizations such as the World Bank do not use local specialists to implement projects and they attribute health problems of the region to poor culture and hygiene. She states that, on the contrary, one of the positive Soviet achievements in the region was a high literacy rate and good hygiene (Ataniyazova, 1998). Saiko reports that a local joke in the communities of Central Asia is that 'if every foreigner who visited this region brought one bucket of water with him, the sea would have been full and the problem would be solved' (Saiko, 1998).

The delays and low success rates of projects may be explained in the realities of rehabilitation. Mainguet (1997) reports that "[e]ven if it were possible to provide the lake with river input of as in the period before 1960, about two centuries would be necessary for the lake to recover!" Estimation of slow recovery is probably due to the current low sea level and the high evaporation rate. McKinney (1996) reports that to restore the Aral Sea to a pre-1960 level would require an annual inflow of approximately 53 km^3 . However to stabilize the sea level at 41-41 m AMSL would take an inflow of $35 \text{ km}^3/\text{yr}$, which may be a more reasonable goal given the regions dependence on irrigated agriculture (McKinney, 1996).

Rehabilitation of the Small Aral

Aladin et al. (1995) reported on an inadvertent attempt at rehabilitating the northern or 'small' Aral sea in their paper titled "The Aral Sea Desiccation and Possible Ways of Rehabilitating its Northern Part" (Figure 5). The actions were actually taken in an attempt prevent a change in the flow of the Syr Darya that would have cut the small Aral Sea off from the river's flow completely (Aladin et al., 1995).

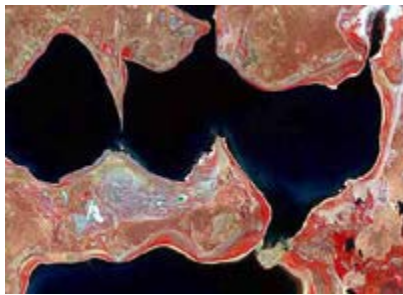


Figure 5. Aral Sea, 1989. Satellite image.

The flow in the Syr Darya increased and the level of water in the Northern Aral began to rise in 1990 (Aladin et al., 1995). Mainguet (1997) reports that the increase in river flow, approximately 10 to 15 km³, was due to diversion of agricultural drainage waters- that were formerly placed in natural depressions - back into the rivers. By diverting field drainage into these depressions, the Sary Kamysh and the Arnasai, the water table was raised and dissolved salts migrated closer to the surface of the soil, as well as waterlogging pastureland and contaminating freshwater wells (Tsukatani, 1998). The diversion of the field drainage *back* into the rivers was done to reduce this affect. The river water that is diverted from the Syr Darya for the purpose of flushing salts from the salinized soils is now returned to the river and eventually makes its way to the small Aral Sea.

Due to the increase in water level in the northern Aral, a small stream began to flow through the previously dry Berg Strait, located between the small and large Aral Seas. Eventually, as the stream began to cut deeper and wider, more and more of the Syr Darya's flow began to drain directly into the large Aral. In the spring of 1992 Aladin et al. (1995) measured a considerable increase in flow from the small to the large Aral. If the stream running through the Berg Strait continued to cut back into the mouth of the river it could divert the flow of the Syr Darya entirely into the southern Aral. The government of Kazakhstan decided to try to prevent the small Aral from disappearing (Aladin et al., 1995).

Aladin et al. (1995) makes no mention of the World Bank or the Committee for Water Resources in relation to this project in their paper. The World Bank proposed several hydrologic improvements in October 1996 and in a project description claims that the 1992 activities in the northern Aral Sea were implemented by the Committee for Water Resources (World Bank, 1998).

In July of 1992 the Berg Strait was filled with sand and a dam was built. Within a few days, however, the dam failed under the pressure of the rising water. The government of Kazakhstan was persistent, and the second dam built at the end of July and beginning of August 1992 was able to withstand the pressure of the filling sea. The small dam, only 1 meter high was built across the width of the strait. The blowing sands worked in their favor, as it built up and fortified the south side of the dam with hills up to two or three meters high. Many sandbanks running parallel to the dam created by wave action also protected the north side (Aladin et al., 1995).

Positive and Negative Effects

Immediately after the second dam was built the small Aral began to change. The level rose by more than a meter in less than 9 months and the water began to freshen. Numerous kinds of wildlife returned to the small Aral including many species of birds coming to nest and feed among the massive growth of reeds that occurred. These included pelicans (*Pelicanus crispus*), great cormorants (*Phalacrocorax carbo*), and many species of ducks. Many critters took advantage, and flourished in the fresh or brackish water branches of the Syr Darya delta including the amphipod *Dikerogammarus aralensis* and the mysid *Paramysis lacustris*. In the short span of time between the fall of 1992 and the spring of 1993, life began to return to the estuary of the Syr Darya and the northern Aral Sea (Aladin et al., 1995).

The negative effects were restricted to the large Aral. They include a moderate increase in reduction of the level of the large Aral. In addition there was a slight increase in the salinity of the large Aral, although this is negligible considering that the flow from the small to the large was not fresh water but saline. Therefore the increase in salinity is more related to evaporation rather than the loss of fresh inflow (Aladin et al., 1995, World Bank, 1998). Aladin et al. (1995) suggest that if a proper dam were to be built the overflow of surplus water would fortify the large Aral and these negative impacts would be reduced.

Unfortunately, even the second dam was not strong enough. It only lasted 9 months and in the spring of 1993 it failed. The flow to the large sea was less than the previous spring, however, since what was left of the dam and the dunes that fortified it still protected the delta (Aladin et al., 1995).

Since this project was not a rehabilitation effort by design, there were no true success indicators. The ultimate goal was to prevent the small Aral from being cut off from the Syr Darya. This goal was achieved even though the dam failed since the remains of it still protected the delta and the straight (Aladin et al., 1995).

Many scientists of the region suggested building a dam between the large and small Aral Seas. Aladin et al. (1995) suggested that the dam be re-built to due to the success of the recovery in the short time it existed. Aladin et al. (1995) suggest that if the Syr Darya's flow could be increased to several cubic kilometers per year, the small Aral Sea could quickly become a freshwater sea. They also suggested that a more sound structure be used, a structure at least 12-14 meters high would be required. Aladin et al. (1995) also hypothesized that with sufficient flow from the Syr

Darya, a water level similar to that in 1970 might be achieved. This increase would require more efficient use of irrigation water and/or a reduction in irrigation.

Even more encouraging is a recent report in the Christian Science Monitor on the third dam to be built on the site. Judith Matloff (1999) reports that a larger dike was built in the straight in 1997, again by the local government. Matloff (1999) reports that the World Bank is considering funding a more permanent fixture. The World Bank website project list contains a description of such a project (World Bank, 1998). The projected appraisal date for the project was October 1998, and the proposed board date was March 1999 (World Bank, 1998). In addition, the United Nations and European donors granted approximately 1 million dollars to clean up the lakeside area and revive traditional livestock and fishing (Matloff, 1999).

Conclusion

It seems that international organizations are applying methods used in other countries to Central Asia with reduced success. Several authors, including Aladin et al. (1995), Saiko (1998), and McKinney (1996), mention the need to focus on the needs and concerns of the local people. Saiko (1998) states that large projects should be downsized and local expertise, cultural and ethnic knowledge be utilized to tend to the immediate concerns of the people of the region. Not only money, but also technology combined with the local skilled labor is necessary to improve irrigation techniques and farming methods thereby reducing waste.

The most urgent needs of the local people include clean drinking water and proper health care. Second in importance is improving the environment around them so they need not rely on sources of food, water and medical assistance from outside their region in the future. Also on the list of needs for the region is reducing their dependence on cotton for economic viability. Once the life threatening issues are attended to, attending to the issues of their environment and economy may create a positive feedback loop. Continuing the vicious circle of cotton production for survival creates a host of deleterious effects. Employing the local people in rehabilitation efforts could have a positive effect on their economy and reduce their dependence on cotton. For example, the government of Kazakhstan could be provided materials to build a dam that will last to rehabilitate the small Aral Sea and provide an alternative resource to agriculture.

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