Simulation of Water Supply and Demand in the Aral Sea Region

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ABSTRACT

The Aral Sea, a huge saline lake located in the arid south-central region of the former U.S.S.R., is vanishing because the inflows from its two feed rivers, the Amudar'ya and Syrdar'ya, have diminished radically over the past three decades. The loss of river flow is the result of massive increases in river withdrawals, primarily for cotton irrigation in the basins. A microcomputer model, the Water Evaluation and Planning System (WEAP), has been developed for simulating current water balances and evaluating water management strategies in the Aral Sea region. WEAP treats water demand and supply issues in a comprehensive and integrated fashion. The scenario approach allows flexible representation of the consequences of alternative development patterns and supply dynamics. For the Aral region's complex water systems, a detailed water demand and supply simulation was performed for the 1987-2020 period, assuming that the current practices continue. The analysis provides a picture of an unfolding and deepening crisis. Policy scenarios incorporating remedial actions will be reported in a separate paper

INTRODUCTION

The Aral Sea, a saline lake located in the arid south-central region of the former U.S.S.R. is vanishing (Fig. 1). Once the fourth largest lake in the world by area, the Aral Sea today is nearing half of its surface area in 1960, less than one-third its previous size by volume. If current patterns continue, the lake will diminish to several residual lifeless brine lakes next century.

The Aral is shrinking because the flows from its two feed rivers, the Amudar'ya and Syrdar'ya, have decreased from over 50 km^3 per year thirty years ago to a mere trickle. The loss of river flow is the result of massive increases in river withdrawals, primarily for irrigation, along the river basins. The two rivers begin at the Pamir and Tianshan plateaus, plunge downward into the desert of the Central Asian republics and terminate at the Aral Sea. Since the 1960s an immense system of dams and reservoirs has been developed in the region. Today, the Aral basin is an astonishingly complex web of canals, impoundments, irrigation fields, and water engineering facilities. The waters in the two rivers are the lifeblood of the agricultural economies in five Central Asian republics of the former U.S.S.R.: Turkmen, Uzbek, Tadzhik, Kirgiz, and Kazakh, supporting 7.6 million hectares of irrigated crops. The current patterns of water use and the recession of the lake has generated multiple environmental and economic problems [1-5]. The scale of these problems is substantial, covering an area of 3.5 million km^2 and affecting some 35 million inhabitants in the five republics. There is an international consensus that the situation is not ecologically sustainable and comprehensive strategies for altering water development patterns are needed.

Beyond the deterioration of the lake and the loss of its fishing industry, there are other serious impacts. For example, the recession of the sea has created a huge area — about 30,000 km^2 — of salt on the former lake bed, Toxic to humans and deleterious to crops, the salt is whipped up by winds and carried over wide areas. The ecology of the river deltas has been seriously degraded as the surrounding water

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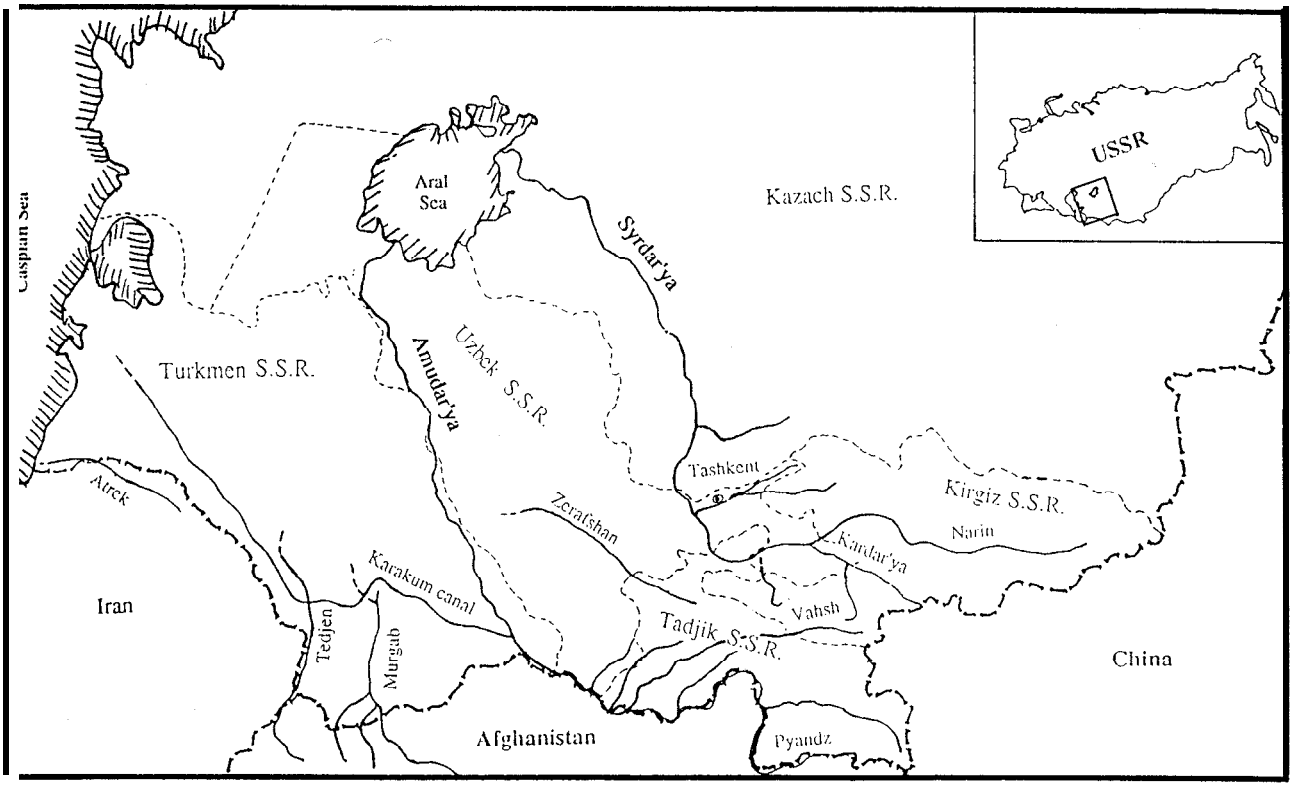

Figure 1. A map of the Aral Sea Region.

table falls along with the sea, and river flow diminishes. In addition, regional climate may be changing as the modulating influence of the Aral diminishes with its size, with summers and winters apparently becoming more severe [2]. Shorter growing seasons, compounded by soil salinization and salt storm deposits, would expand water shortages by further increasing the requirements for water. Last, but not least, there is great concern that deteriorating water quality will lead to a deepening public health crisis.

Regional climate may be changing as the modulating influence of the Aral diminishes

A microcomputer model, the *Water Evaluation and Planning System* (WEAP), was developed for evaluating alternative water development policy options in complex systems such as the Aral Sea region [6]. Employing the scenario approach, the WEAP model provides a structured approach to integrated water demand-supply analysis.

This paper presents results of a "business-as-usual" simulation of the region's water supply for the 1987-2020 period, assuming that the current practices continue. Development and evaluation of alternative water policy scenarios will be reported in future papers. In this paper, we focus on illustrating the magnitude of the problem and the challenge for devising sustainable water strategies for the Aral region.

CURRENT WATER DEMAND AND SUPPLY

Comprising lowland deserts and mountains, the Aral region has a climate characterized by high evapotranspiration and severely arid conditions. Annual precipitation is less than 100 mm in the southwest deserts and about 200 mm approaching the foothills of the southeastern mountains. However, the region has favorable thermal conditions for the growth of cotton and other heat-loving crops: the average noontime temperature during growing seasons (May-September) reaches 20-45°C and the average daily temperature in July is 35°C [7]. Although thin and infertile, soil in the region is easily tilled and productive for certain crops with the application of supplementary water. These favorable conditions have provided the natural base for intensive irrigated agricultural development, particularly the large scale production of cotton in the Aral region.

The Amudar'ya and Syrdar'ya basins have some 30 primary tributaries (Figs. 2 and 3). More than 20