

Title:

Inexact fractional optimization model for planning water resource system of the Aral Sea basin

Abstract:

The Aral Sea basin is one of the most prominent areas in the world where the contradiction between supply and demand of water resource and the ecological environment problems; its ecological disasters in the 20th century have aroused wide attention of the international community. The complexity of planning and management for the Aral Sea basin lies in the dynamically temporal and spatial variation of water resource supply and demand information; at the same time, the supply state and demand type of water resource are also complex variables. These complexities, along with their inherent multiple uncertainties, form a series of challenging issues related to watershed sustainable management. Therefore, this study aims to propose a set of inexact fractional programming methods for optimizing water resource system of the Aral Sea basin, which can tackle random variables under conflicting objectives and analyze the interrelationship between marginal benefit and system-failure risk. The obtained results can help balance the contradictions among water shortage, economic development, and ecology protection, as well as provide synergic management strategies. Some suggestions can be derived from the results to support sustainable development of the Aral Sea basin: (i) it is desired to reduce agricultural water consumption through improving irrigation efficiency (e.g., reducing flood irrigation and increasing drip or spray irrigation) and adjusting crop structure and area; (ii) compared to the conventional approaches, the inexact fractional programming method can generate more flexible alternatives and achieve higher marginal effectiveness; (iii) compared to the single management pattern, the integrated optimization of water, food, energy and ecology not only has higher efficiency of resources allocation and utilization, but also allows an increased robustness in controlling system-failure risk under uncertainty.