

Title:

Bi-level-based chance-constrained programming methods for supporting sustainable development of Central Asia under uncertainty

Abstract:

Issues of water scarcity, food crisis, and ecological degradation pose great challenges to the sustainable development of Central Asia. Effectively synergetic management of water-food-ecology (WFE) nexus system is desired, which may alleviate water shortage, ensure food security, and improve ecological environment. In this study, two bi-level-based chance-constrained programming methods are developed for planning water-food-ecology (WFE) nexus system of the Aral Sea basin (Central Asia). The developed methods have advantages in balancing the tradeoffs between two-level decision makers in hierarchical structure and reflecting the synergies among multiple sub-systems under random uncertainty. Besides, water trading mechanism is introduced into the optimization framework to alleviate water scarcity, food crisis, and ecological degradation. Multiple scenarios with different combinations of food demand, ecological water requirement and water availability are examined. Results about water resources allocation to agricultural, domestic, industrial, municipal, and ecological users are obtained, which are used for revealing the interrelationships among multiple competing users. Compared with the conventional single-level optimization approach, the synergetic management of WFE nexus system based on the proposed bi-level methods can increase food production and ecological water allocation, which is beneficial to the sustainable development of water shortage regions.