

16.干旱区资源环境可持续发展

权衡和协调管理干旱区水-农业-能源-环境耦合关系

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摘要: Water is a stabilizer for production and life in the arid areas. According to research shared by the Pacific Institute and The Guardian, there were 228 incidents of water conflict globally in 2022. Therefore, comprehensive measures are necessary to achieve regional water security. This objective can be achieved by the application of interdisciplinary and professional approaches through establishing a dynamic equilibrium of the different water consumers, and trade-offs and synergies for water allocation between them. A multi-objective optimization model is proposed for managing the water-agriculture-energy-environment (WAE) nexus in water-scarce areas. Real and integer-encoded multi-objective evolutionary algorithms (EMCMO) were applied to solving management models. Multiple objectives, such as the maximization of economic benefits from agriculture and hydropower generation, the minimization of ecological water shortages for local plants, and the minimization of environmental risks influenced by land use and food supply, were defined in the model. The model was applied to the Yanqi Basin, an important agriculture and energy producer in Xinjiang province, Northwest China. The results indicated that (1) the four-dimensional Pareto solution set has the advantage of presenting the WAE nexus, highlighting the trade-offs and synergies between high-value crops, surface water, and groundwater, ecological water demand, hydropower generation and total nitrogen and phosphorus loading (TNP); (2) An excessive increase in the agricultural economy will increase TNP loading and agricultural non-point source pollution; (3) Optimization of WAE for local ecosystem restoration. Optimization in a wet year, reduced agricultural economic benefits by 0.20%, and agricultural TNP loading by 13.19% while increasing ecological water by 58.33%, and hydropower generation by 3.98%; in a normal year, reduced agricultural economic benefits by 6.62%, agricultural TNP loading by 13.19% while increasing ecological water by 46.43%, and hydropower generation by 0.79%; in a dry year, reduced agricultural economic benefits by 17.19%, agricultural TNP loading by 9.72%, and hydropower generation by 16.18% while increasing ecological water by 42.86%. The trade-offs and synergies of the WAE nexus also apply to other similar water-scarce areas.

关键词: multi-objective optimization model, water-agriculture-energy-environment nexus, Yanqi Basin, TNP loading, arid area