Optimal Allocation of Water Resources in the Kaidu-Kongque River Basin (Postprint)

Authors: Wang Wenhui, Huang Yue, Liu Tie, Meng Fanhao, Liu Jiao, Liu Tie

Date: 2018-09-03T00:00:00+00:00

Abstract

Water resources are a critical factor for maintaining the coordinated development of society, economy, and ecological environment in inland river basins. In response to the current situation of water resource shortage, establishing an optimal allocation scheme that balances ecological, production, and domestic water use is an effective means to improve water use efficiency and alleviate the contradiction between supply and demand. This study takes the Kaidu-Kongque River Basin as the research area, employs a two-stage interval optimization algorithm, and constructs a water resource optimization model based on historical meteorological, hydrological, land use, and socioeconomic data to conduct multi-scale optimal allocation (annual, monthly, and decadal) of municipal, ecological, and water use across agricultural, industrial, and service sectors. This method combines the characteristics of interval and probabilistic optimization, enables accurate analysis of uncertainties in multi-source water supply and multi-user water demand, and achieves optimal water resource allocation under different policy scenarios. The research shows that: water demand for municipal, livestock, and secondary/tertiary industries in the basin can be largely met; water shortage mainly occurs in agriculture, ecological water use, and water transfer to the lower Tarim River. In terms of regional distribution, agricultural water shortage is most significant in Korla and Hejing County; ecological water shortage mainly occurs in Bohu County and Korla City, with the ecological water delivery unit in the lower reaches of the Tarim River experiencing the most severe shortage, still facing a deficit of 0.27×108~ 0.92×108 m3 · a-1 even under high inflow conditions. The maximum intra-annual water allocation occurs in July, and the minimum in January; September experiences the highest degree of water shortage, with agricultural and ecological water shortages of 0.36×108~1.43×108 m3 and 0.90×108 m3, respectively. Different water resource management policies will lead to significant changes in basin-wide system benefits; compared with other policy scenarios, the scenario prioritizing economic benefits enables the system to achieve higher water-use benefits, representing a relatively optimal

water resource allocation scheme.

Full Text

Optimized Redistribution of Water Resources in the Kaidu-Kongque River Basin Based on Two-Stage Interval Optimization Algorithm

WANG Wenhui[1,2], HUANG Yue[1], LIU Tie[1], MENG Fanhao[1,2], LIU Jiao[3]

[1]State Key Laboratory of Desert and Oasis Ecology, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, Urumqi 830011, China
[2]University of Chinese Academy of Sciences, Beijing 100049, China
[3]School of Energy and Power Engineering, Xihua University, Chengdu 610039, China

Abstract

Water resources are the key factor for maintaining harmonious social, economic, and ecological development in inland river basins. To address the current water shortage situation in the study area, establishing an optimal water resources allocation plan is an effective method for improving water use efficiency and alleviating the contradiction between supply and demand. This paper takes the Kaidu-Kongque River Basin as the study area, and based on historical, meteorological, hydrological, land use, social, and economic data, uses a two-stage interval optimization algorithm to develop a water resources optimization allocation model. The optimized redistribution schemes for various industries were analyzed, which could precisely analyze uncertainties of water sources and users, and achieve optimized water resources allocation. The results show that water consumption for urban residents, animal husbandry, and secondary/tertiary industries can be basically satisfied, while water shortages are severe in agriculture, ecology, and ecological water conveyance to the lower reaches of the Tarim River. Regionally, agricultural water shortage occurs mainly in Korla City and Hejing County, ecological water shortage occurs mostly in Bohu County and Korla City, and the water shortage for the lower Tarim River ecological conveyance is most serious in high-flow years, reaching 0.27×10 -0.92×10 $m^3 \cdot a^{1}$. The highest and lowest water shortages occur in July and January respectively; the most severe shortage occurs in September, with agricultural and ecological water shortages of 0.36×10 -1.43×10 m^3 and 0.90×10 m^3 respectively. Different water management policies could lead to significant changes in system benefits. Compared with other policy scenarios, the system prioritizing economic benefits could achieve higher water use efficiency.

Keywords: two-stage interval optimization algorithm; water resources; optimized water redistribution; policy analysis; inland river basin

Figures and Tables

[Figure 1: see original paper] Sketch map of the study area

[Figure 3: see original paper] Optimized annual water volumes for different industries in all the counties (cities)

[Figure 5: see original paper] Optimized monthly water volumes for different industries

[Figure 6: see original paper] Optimized water volumes for all the counties in April and July

[Figure 7: see original paper] Optimized water volumes for different industries in April and July

[Figure 8: see original paper] Compared results of redistributed water volumes for different industries under different conditions

Comparison of comprehensive benefits under different conditions (10 $m^3 \cdot a^{1}$)

References

[1] Zhao Xiang, Chen Jijiang, Mao Hongxiang. An evaluation of the coordinated development of water resources, social economy and eco-environment[J]. China Rural Water and Hydropower, 2009(9): 58-62.

[2] Deng Qinghai, Pan Guoying, Jia Junhui, et al. GIS-based optimized management information system of water resources: A case study on the management of water resources in Puyang[J]. Arid Zone Research, 2004, 21(1): 17-20.

[3] Yang Aimin, Tang Kewang, Wang Hao, et al. Theory and calculation method of ecological water use[J]. Journal of Hydraulic Engineering, 2004, 35(12): 39-45.

[4] Wang Weixia, Wang Xiujun, Jiang Fengqing, et al. Response of runoff volume to climate change in the Kaidu River Basin in recent 30 years[J]. Arid Zone Research, 2013, 30(4): 743-748.

[5] Wang Shuixian. Study on Effect of Oasis Water and Land Resources Development and Environment in Kaidu-Kongque Basin[D]. Urumqi: Xinjiang Agricultural University, 2008.

[6] Wang Hao, Qin Dayong, Guo Mengzhuo, et al. Model and calculation method for rational water resources allocation in arid zone[J]. Advances in Water Science, 2004, 15(6): 689-694.

[7] Huang Y, Chen X, Li Y, et al. A simulation-based two-stage interval optimization program for water resources allocation in arid zone[J]. Journal of Hydraulic Engineering, 2008, 39(2): 183-188.

[8] Huang Shihua, Zhang Shiting, Qin Yanyan, et al. Monthly SPI and water resource allocation in Zhangye Area within the years of 1951-2010[J]. Journal of Lanzhou University (Natural Sciences Edition), 2013(4): 511-514.

[9] Li Linlin. Multi-water resource optimization based on inexact two-stage stochastic programming[J]. Heilongjiang Science and Technology of Water Conservancy, 2015, 43(11): 10-13.

[10] Xie Gaodi, Zheng Lin, Lu Chunxia, et al. Expert knowledge-based valuation method of ecosystem services in China[J]. Journal of Natural Resources, 2008, 23(5): 911-919.

[11] Wang Liu, Duan Ying. Analysis of vegetation distribution based on remote sensing[J]. Natural Resources, 2012, 35(3): 140-142.

[12] Xie Gaodi, Zhang Caixia, Zhang Leiming, et al. Improvement of the evaluation method for ecosystem service value[J]. Resources and Environment in Western China, 2015, 30(8): 1243-1254.

[13] Zhang Jiafeng, Chen Yaning, Li Weihong, et al. The demand analysis of water resources in Kaidu river-Kongque river drainage basin[J]. Arid Zone Research, 2011, 48(10): 1929-1935.

[14] Wang Liu. Multi-objective decision-making model for water resources allocation in Western China[M]. Zhengzhou: The Yellow River Water Conservancy Press, 2012.

[15] Wang Hao, Qin Dayong, Guo Mengzhuo, et al. Model and calculation method for rational water resources allocation in arid zone[J]. Advances in Water Science, 2004, 15(6): 689-694.

[16] Zhang Jiafeng, Chen Yaning, Li Weihong, et al. The demand analysis of water resources in Kaidu river-Kongque river drainage basin[J]. Arid Zone Research, 2011, 48(10): 1929-1935.

[17] Huang Y, Chen X, Li Y, et al. A simulation-based two-stage interval optimization program for water resources allocation in arid zone[J]. Journal of Hydraulic Engineering, 2008, 39(2): 183-188.

[18] Wang Shuixian. Study on Effect of Oasis Water and Land Resources Development and Environment in Kaidu-Kongque Basin[D]. Urumqi: Xinjiang Agricultural University, 2008.

[19] Wang Hao, Qin Dayong, Guo Mengzhuo, et al. Model and calculation method for rational water resources allocation in arid zone[J]. Advances in Water Science, 2004, 15(6): 689-694.

[20] Xie Gaodi, Zheng Lin, Lu Chunxia, et al. Expert knowledge-based valuation method of ecosystem services in China[J]. Journal of Natural Resources, 2008, 23(5): 911-919.

[21] Wang Liu, Duan Ying. Analysis of vegetation distribution based on remote sensing[J]. Natural Resources, 2012, 35(3): 140-142.

[22] Xie Gaodi, Zhang Caixia, Zhang Leiming, et al. Improvement of the evaluation method for ecosystem service value[J]. Resources and Environment in Western China, 2015, 30(8): 1243-1254.

[23] Zhang Jiafeng, Chen Yaning, Li Weihong, et al. The demand analysis of water resources in Kaidu river-Kongque river drainage basin[J]. Arid Zone Research, 2011, 48(10): 1929-1935.

[24] Wang Liu. Multi-objective decision-making model for water resources allocation in Western China[M]. Zhengzhou: The Yellow River Water Conservancy Press, 2012.

Note: The original text contained significant encoding errors and corrupted content in the main body sections. Only the title, author information, abstract, keywords, references, and figure/table captions were fully recoverable. The translation focuses on these coherent sections while preserving all mathematical expressions, citations, and academic formatting.

Note: Figure translations are in progress. See original paper for figures.