Determination of Irrigation Allocation Policy under Climate Change by Genetic Programming

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Abstract: This paper develops and evaluates rule curves of reservoir operation and compares them for baseline and future periods. The rules are calculated by genetic programming (GP). Also, the rules extracted are based on the rate of inflow, storage volume, and downstream irrigation network demand. The objective function used is the minimization of the average of squared monthly relative deficiencies in the allocation of water to irrigation demand. The study focuses on the reservoir system as well as the downstream irrigation network of Aidoghmoush dam in East Azerbaijan, Iran, under baseline conditions (time interval 1987–2000) and climate change conditions (time interval 2026–2039). To investigate the optimal allocation policy, three operational scenarios are considered: (1) development of current rules under baseline conditions; (2) employment of current rules for future conditions; and (3) development of future rules for future conditions. Results show that the current allocation policy (resulting from current optimal rules) should be modified under climatic change conditions. Also, the investigation indicates that the application of a future optimal allocation policy under future conditions relative to current rules under current conditions decreases (improves) the root-mean-square error (RMSE) and mean absolute error (MAE) performance criteria approximately 29 and 30%, respectively. In addition, efficiency indicators in the optimal allocation of reservoir water are calculated under climate change (policy used in the third operational scenario) and compared with its corresponding values in baseline conditions. Results show that under climate change conditions as compared to the baseline period, indexes of reliability, vulnerability, and resiliency, respectively, decrease 50%, increase 6%, and decrease 14%. Awareness of this issue by planners and decision makers can propel them to reduce the volume of network water requirements. This may be realized through changes, e.g., in the cropping pattern and cultivation area. **DOI: 10.1061/(ASCE)IR.1943-4774.0000807.**

Author keywords: Rule curve; Climate change; Genetic programming; Efficiency indicators; Allocation policy.

Introduction

In general, population growth and consequently water demand increase, on the one hand, and water resources limitation, on the other hand, reveal the need to properly allocate and manage water resources. An increase in greenhouse gas emissions will exacerbate changes in the Earth's climatic variables [Intergovernmental Panel on Climate Change (IPCC) 2007]. Exacerbation of climatic parameter changes in future periods may have different effects on various systems, including water resources, agriculture, and all systems that are in interaction with the climatic system.

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Recently, many techniques have been developed and applied in all aspects of water resources systems such as reservoir operation (Bozorg Haddad et al. 2008b, 2009, 2011a; Afshar et al. 2010; Fallah-Mehdipour et al. 2011b, 2012), cultivation rules (Moradi-Jalal et al. 2007; Noory et al. 2012), pumping scheduling (Bozorg Haddad and Mariño 2007; Rasoulzadeh-Gharibdousti et al. 2011), water-distribution networks (Bozorg Haddad et al. 2008a; Soltanjalili et al. 2011; Fallah-Mehdipour et al. 2011a; Seifollahi-Aghmiuni et al. 2011; Ghajarnia et al. 2011; Sabbaghpour et al. 2012), operation of aquifer systems (Bozorg Haddad and Mariño 2011), and site selection of infrastructures (Karimi-Hosseini et al. 2011). Only a few of these papers dealt with the determination of irrigation allocation policy under climate change.

Hsu et al. (2004) presented applicability of reservoir operation rule curves in Taiwan. Their study detected that the drought events by the prediction data and water resource system model optimized the double-group rule curves and made the water resources more flexible in meeting the demands.

Payne et al. (2004) evaluated effects of climate change on reservoir operation policies for objectives of flood control, power production, fish, and recreation. They showed that hydrological changes resulting from this phenomenon led to changes in reservoir operation policies. After examination of several alternatives related to reservoir operation policies, it was specified that a combination of earlier reservoir refill with greater storage allocations for in-stream flow lead to mitigation of the climate change negative impacts on flow. This caused significant losses in firm hydropower production.

Nagesh Kumar et al. (2006) presented a genetic algorithm (GA) for obtaining an optimal operating policy and optimal crop water