Climate Change Impact on Reservoir Performance Indexes in Agricultural Water Supply

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Abstract: This paper addresses the impact of climate change on the volume of inflow to a reservoir and the volume of downstream water demand by considering three climate change scenarios in an East Azerbaijan river basin. The HadCM3 model was used to estimate possible scenarios of temperature and rainfall for the period 2026–2039 under an emission scenario (A2). A hydrological model (IHACRES) was first calibrated for the basin; and then, a monthly time series of future temperatures and rainfall were entered into IHACRES. In addition, a 14-year time series of monthly runoff was simulated for 2026–2039. Modeling results indicated that the average long-term annual runoff volume decreased by 0.7% relative to the base period (1987–2000). However, by assuming a nonchanging cultivation area, the average long-term annual water demand volume for crops increased by 16%. Both simulation and optimization models of reservoir operation were used. The simulation of reservoir performance in the delivery of water demand was implemented according to the standard operating policy (SOP) and by using the water evaluation and planning (WEAP) model. The three aforementioned climate change scenarios were then introduced to the WEAP, and the reservoir performance indexes (reliability, vulnerability, and resiliency) were calculated. Results showed that indexes would change in the future relative to the base. Next, for the optimal operation of the reservoir with a water supply for agricultural and environmental purposes, the minimization of total squared deficiencies in the allocation to these purposes was determined for each month and climate change scenario by the using LINGO Version 11.0 software [nonlinear programming (NLP)] algorithm. Results showed that the indexes would change. **DOI: 10.1061/(ASCE)IR.1943-4774.0000496.** *© 2013 American Society of Civil Engineers.*

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Introduction

Because of intensified human activity, growing population, and greenhouse gas emissions, most regions of the Earth are expected to experience significant increases in mean annual temperature (>2°C) by the end of the present century [Intergovernmental Panel on Climate Change (IPCC) 2007]. The linear warming trend over the last 50 years (0.13°C per decade) is nearly twice that for the last 100 years. Studies of other climatological parameters, such as rainfall, cloudiness, and evaporation, have shown strongly varying trends on both global and regional scales (IPCC 2007). Without doubt, this phenomenon, called climate change, not only has been affecting climatic variables but also extreme events (e.g., droughts and floods), although it is not widely recognized (Robson 2002). Several studies (Muzik 2001; Boyer et al. 2010) have shown that small perturbations in rainfall frequency and/or quantity can result in significant impacts on the mean annual discharge of rivers. Moreover, Christensen et al. (2004) indicated that modest changes in natural inflows result in larger changes in reservoir storage. Any changes in the hydrologic cycle will affect energy production and flood control measures (Xu and Singh 2004) to such an extent that water management adaptation measures will very likely be brought in. Anthropogenic climate change will affect water resources and agricultural consumption sectors in developing and developed countries. For example, in Iran, the agricultural sector is the primary water consumer and, thus, the study and evaluation of climate change impact on agricultural water supply is essential.

The common step that should be considered in all of these studies is climatic data simulation (such as temperature and rainfall) for the future. The most reliable and common instruments for obtaining projections of future global climate change are the fully coupled atmospheric-ocean general circulation models (AOGCMs) (Wilby and Harris 2006). According to their needs, investigators use a single general circulation model (GCM) or multiple models. On the other hand, investigations that examine the impacts of climate change show that these studies are mostly limited to assessing the effects of an upstream dam (water resources) or a downstream demand (water consumptions) (Quinn et al. 2004; Steele et al. 2008; Knox et al. 2010; Boyer et al. 2010). In contrast, climate change impact assessment and adaptation with the negative effects of this phenomenon emphasize the involvement of stakeholders in the framework of integrated water resources management (IWRM). Purkey et al. (2007) reported on the application of the water evaluation and planning model (WEAP) in the Sacramento River basin to study the impact of climate change on agricultural water management and its potential for adaptation. The WEAP model

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