Evaluation of the Impacts of Climate Variability and Human Activity on Streamflow at the Basin Scale

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Abstract: This paper analyzes long-term trends and sudden changes in hydro-climatic variables (i.e., runoff) in Iran's Aidoghmoush basin during 1971–2000 using the nonparametric Mann-Kendall test and curves of cumulative runoff versus rainfall and cumulative runoff versus temperature The use of the Mann-Kendall test with a 99% confidence level revealed a decreasing trend in annual rainfall and total runoff and an increasing trend in temperature. A sudden change in the gradient of the cumulative curves in 1988 indicated that the relation between climatic variables and runoff is influenced by human activities (agricultural water use). The interval 1971–2000 was separated into a baseline interval (1971–1988) and an impact interval (1989–2000), during which human activities affected runoff. The five-parameter hydrologic model of IHACRES (Identification of unit Hydrographs and Component flows from Rainfall, Evaporation, and Streamflow data) was calibrated and verified over the baseline interval to determine the contribution of human activities and climatic variability to the change in runoff. Runoff was simulated with the hydrologic model for the interval 1989–2000, during which human activities reduced runoff. Results show that climate variability and human activities decreased the runoff in the Aidoghmoush river basin by 79 and 21%, respectively. **DOI: 10.1061/(ASCE)IR.1943-4774.0001038.**

Author keywords: Climatic variability; Human activities; Runoff; Hydrologic models.

Introduction

Many previous works in water resources systems dealing with reservoir operation (Ahmadi et al. 2014; Bolouri-Yazdeli et al. 2014), groundwater resources (Bozorg-Haddad et al. 2013; Fallah-Mehdipour et al. 2013b), conjunctive use operation (Fallah-Mehdipour et al. 2013a), design-operation of pumped-storage and hydropower systems (Bozorg-Haddad et al. 2014), flood management (Bozorg-Haddad et al. 2015b), water project management (Orouji et al. 2014), qualitative management of water resources systems, (Orouji et al. 2013; Shokri et al. 2014; Bozorg-Haddad et al. 2015a), water distribution systems (Seifollahi-Aghmiuni et al. 2013; Soltanjalili et al. 2013; Beygi et al. 2014), sedimentation (Shokri et al. 2013), and irrigation water allocation (Ashofteh et al. 2015b) have commonly focused on historical data for analysis purposes. Climatic variability and human activities, such as change in land use and construction of water resources projects, add to the complexity of hydrological processes. Recent investigations (Ashofteh et al. 2013a, b) have evaluated the effects of climate change on hydrology and water resources. Yet, most studies have disregarded changes in land use and land cover, even though rapid population growth, agricultural development, and land use changes are important factors that contribute to modifications in the hydrological regime (Cong et al. 2009). It is, therefore, essential to consider the effects of climate variability and human activities on hydrologic processes to achieve sustainable water management strategies.

Various approaches have been reported in the literature that have dealt with climate-change effects on water supply. Several of those studies analyzed the effects of climate variability and human activities on hydrologic processes. For example, Lørup et al. (1998) assessed long-term impacts of land use change on catchment runoff in semiarid Zimbabwe. A methodology combining common statistical methods with hydrological modeling was adopted to separate between the effects of climate variability and the effects of land use change. For this purpose the hydrological model (NAM) was applied to simulate the observed hydrographs and to provide a means to account for the effects of climate variability. In the test period, the validated model was used to provide the runoff record, which would have occurred in the absence of land use change. Their results showed a decrease in the annual runoff, with the largest changes occurring for catchments located within communal land, where large increases in population and agricultural intensity had taken place.

Motondo et al. (2004) evaluated the impact of climate change on hydrology and water resources in three U.K. catchments by using the geophysical fluid dynamics laboratory (GFDL), the United Kingdom transient resilient (UKTR) model, and the Canadian climate change equilibrium (CCC-EQ) general circulation models (GCMs) as inputs to a WatBall rainfall-runoff model. Kirono et al. (2006) investigated impacts of climate change on water resources in Australia. The rate of global warming was extracted from six atmosphere-ocean global circulation models (AOGCM), in the 2010s, 2020s, and 2030s. Gunawardhana et al. (2011) evaluated the impacts of urbanization and climate change on groundwater, especially aquifer temperature in the Sendai plain, Japan. Harma

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