

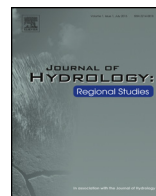


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Contents lists available at ScienceDirect

Journal of Hydrology: Regional Studies

journal homepage: www.elsevier.com/locate/ejrh



Hydrological responses to climate change in Mt. Elgon watersheds



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ARTICLE INFO

Article history:

Received 5 June 2014

Received in revised form 3 December 2014

Accepted 8 December 2014

Available online 12 January 2015

Keywords:

Climate change

Streamflow

Nzoia basin

Mt. Elgon

SWAT

ABSTRACT

Study Region: The Upper catchments of the Nzoia River basin in western Kenya.

Study Focus: The potential streamflow responses to climate change in the upper Nzoia River basin are studied. The Soil and Water Assessment Tool (SWAT) was forced with monthly temperature and precipitation change scenarios for the periods 2011–2040 (2020s), 2041–2070 (2050s) and 2071–2100 (2080s). Data from 10 climate models and three greenhouse gases emission scenarios was down-scaled using the delta change method and used in the SWAT model. Streamflow data for the periods 1986–1998 and 1973–1985 was used for model calibration and validation respectively.

New Hydrological Insights for the Region: Comparison between the simulated baseline and future streamflow shows that in the Koitobos and Kimilili watersheds, August to December streamflow is likely to be highly altered. In the Kuywa watershed, March to June flows is likely to change considerably due to climate change. Major streamflow changes are likely in March to June and August to November in the Rongai watershed. Projected changes differed between the four watersheds despite their proximity, indicating different sensitivities to climate change and uncertainty about the potential hydrological impacts of climate change in the area.

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1. Introduction

Increasing concentrations of atmospheric greenhouse gases (GHGs), and consequent global warming are almost certainly responsible for significant changes in global climatic patterns (IPCC, 2007; Xu et al., 2011). Climate change impacts are most severely experienced by communities whose livelihoods are heavily dependent on climate-sensitive sectors such as agriculture, water resources and forestry (Xu et al., 2013). Shifts in the availability of water resources are expected to be among the most significant consequences of projected climate changes (IPCC, 2007; Kingston and Taylor, 2010). Perturbations to the hydrological system will have implications for runoff volume and timing, ecosystem dynamics, social and economic systems. The intensity of the impacts at local level and the vulnerability of communities and ecosystems to these impacts are highly dependent on the particular characteristics of the area, as well as the magnitude and spatial distribution of the changes that will be experienced (Hagg et al., 2007; Matondo et al., 2004).

Given the vital role of water resources in socio-economic development, the potential hydrological impacts of climate change pose a significant challenge for water resource planning and management. Consequently, such impacts of climate change have been widely studied, mainly using water balance models coupled with General Circulation Models (GCMs). Impacts have been attributed to the associated long-term changes in the dominant climate variables: precipitation and temperature (Chien et al., 2013; Hansen et al., 2006). The hydrological simulations based on climatic projections have shown relatively minor dependence on the hydrological model used compared to the choice of climate models (Bates et al., 2008; Kay et al., 2006). Although GCMs are primary tools for climate change impact assessment, there is a mismatch between the fine-scale nature of local hydrological processes and the coarse resolution of GCMs. Consequently, downscaling techniques varying in complexity and approach have been developed and used (Liu et al., 2008; Murphy, 1998; Wilby and Wigley, 1998; Xu, 1999).

Despite the growing interest in assessing the hydrological impacts of climate change, the underlying uncertainties in simulation of hydrological responses to climate change are still a challenge. Under stable climate conditions and/or physical characteristics, errors in the model structure, calibration procedure, and calibration data are the main sources of uncertainties (Bastola et al., 2011; Brigode et al., 2013; Yang et al., 2008). In non-stationary conditions, such as will occur under climate change, the coarse resolution of the climate models, their representation of the atmospheric and other processes, and differences in results of downscaling techniques are key concerns (Braga et al., 2013; Chiew et al., 2010; Ficklin et al., 2009; Minville et al., 2008; Teng et al., 2012; Xu et al., 2011). Although the relative significance of the different sources of uncertainty has not often been quantified, studies have shown that uncertainties from GCM outputs are more significant than those from hydrological models (Arnell, 2011; Chen et al., 2011; Teng et al., 2012).

In the Nzoia River basin, the target area of this study, historical occurrence of extreme hydrological conditions with dire consequences for local populations have already exposed the vulnerability of human and natural systems to hydrological changes. Land use on the slopes of Mt. Elgon is characterized by conflict between conservation measures and subsistence farming. Frequent landslides and floods initiated by high rainfall and land degradation in the area have claimed lives and destroyed property in the recent past (Claessens et al., 2007). The area is endowed with a rich biodiversity, which influences lives and livelihoods of thousands of people through provision of ecosystem services and products (Petursson et al., 2006). This area forms the upper reaches of the Nzoia River and contributes a significant proportion to its streamflow volume. However, climate change is likely to affect hydrological processes, possibly increasing the vulnerability of farmers to natural variation. Assessment of the potential climate change impacts on streamflow is therefore crucial for disaster preparedness, irrigation planning and structural development. Since the area has not received adequate attention in climate change impact assessment, this study seeks to assess the potential impacts of climate change on streamflow in Mt. Elgon watersheds using the Soil and Water Assessment Tool (SWAT). An ensemble mean for ten GCMs and three greenhouse gas emissions scenarios (A1B, A2 and B1) was used to create future scenarios to run the calibrated and validated SWAT model.

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