Theoretical and Applied Climatology
https://doi.org/10.1007/s00704-023-04372-w

ORIGINAL PAPER

Assessment of climate change impacts on the hydrological response of a watershed in the savanna region of sub-Saharan Africa

Murtala Iyanda Animashaun[1,2] · **Philip Gbenro Oguntunde**[2] · **Obafemi Olutola Olubanjo**[2] · **Akinola Shola Akinwumiju**[3]

Received: 3 November 2021 / Accepted: 10 January 2023

Abstract

In this study, the applicability of ensemble mean from Coordinated Regional Climate Downscaling Experiment_Regional Climate Models (CORDEX_RCMs) for climate change impact assessment on Niger Central Hydrological Area (NCHA) was evaluated. Thereafter, the Soil and Water Assessment Tool (SWAT) model was successfully calibrated at the Kaduna sub-basin. The SWAT model was then forced with the CORDEX_RCMs at four specific global warming levels (GWLs) (i.e., 1.5 °C, 2.0 °C, 2.5 °C, and 3.0 °C) and the baseline (1971–2000). The water balance components (WBCs) generated at GWLs were compared with the baseline. The results indicate that the CORDEX_RCMs effectively simulated climate variables. The past and future projections (1950–2100) show an increase in annual streamflow of 4.7%, 5.9%, 3.4%, and 3.5% at 1.5 °C, 2.0 °C, 2.5 °C, and 3.0 °C, respectively, over the baseline. Similarly, with respect to baseline, changes are expected in average annual rainfall (+1.91%, +2.64%, +2.33%, and +2.41%), runoff (+1.37%, +3.81%, +1.17%, and +3.26%), potential evapotranspiration (+2.85%, +4.09%, +6.54%, and +6.60%), and evapotranspiration (−2.15%, −2.62%, −4.00%, and −4.33%) under 1.5 °C, 2.0 °C, 2.5 °C, and 3.0 °C, respectively. Monthly streamflow for the dry and early rainy seasons is projected to decrease, while the late rainy season is expected to increase with an increase in GWLs. The implication is that while there may be a lack of water in the early rainy season, the flood event presently being witnessed in the late rainy season may become aggravated. Hence, adaptation strategies that take care of water deficit in the early rainy season and excess in the late rainy season should be put into consideration.

1 Introduction

Climate change is anticipated to have impacts on hydrological conditions and water resource systems at global and regional scales. Consequently, rainfall events, water yield, evapotranspiration, and surface runoff of every basin are expected to experience either an upward or downward shift in trend-line in response to the change (Pandey et al. 2017). The frequency, magnitude, and severity of one or more components of the aforementioned hydrological processes are likely to have diverse impacts on the environmental variables and socio-economic sectors of every region. Some regions may experience a situation of less than the required volumes of water, leading to water shortage or stress, while others may have excess water. Either of the two situations attracts hydrological extreme events of drought or flood (Oguntunde and Abiodun 2013). These pose a serious threat to virtually all sectors particularly agriculture as effective rainfall for agriculture is supposed to be adequate in terms of frequency, duration, and magnitude. The negative effects of otherwise may be felt through the decline in crop yield; hence, the risk of hunger and poverty may be on the increase (Abbaspour et al. 2009). Developing nations are more vulnerable to the impacts of climate change as rain-fed agriculture remains a major driving force of their economy (Animashaun et al. 2020). Of particular interest among the developing nations are the West African countries particularly those that fall within River Niger trans-regional basins.

Climate variables (particularly rainfall) over Niger River Basin (NRB) are very variable both on the spatial and temporal scale (Okpara et al. 2013). The temporal variability is

✉ Murtala Iyanda Animashaun
ai.iyanda@futminna.edu.ng

1 Department of Agricultural & Bioresources Engineering, Federal University of Technology, Minna, Nigeria

2 Department of Agricultural & Environmental Engineering, Federal University of Technology, Akure, Nigeria

3 Department of Remote Sensing and Geoscience Information System, Federal University of Technology, Akure, Nigeria