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Impacts of climate change on streamflow and sediment concentration under RCP 4.5 and 8.5: A case study in Purna river basin, India

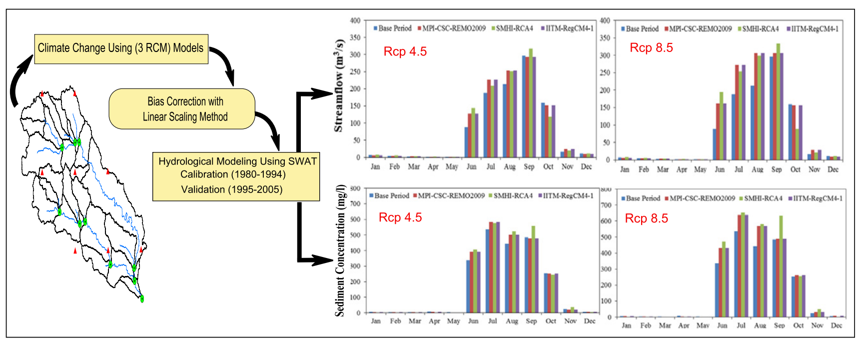
Aditya P. Nilawar *, Milind L. Waikar

Department of Civil Engineering, Shri Guru Gobind Singhji Institute of Engineering and Technology (SGGS IE &T), Nanded 431605, India

HIGHLIGHTS

- Future climate data were generated by three climate model for RCP 4.5 and 8.5.
- Projected precipitation and temperature indicated an increasing trend in all season.
- Streamflow and sediment concentration were found to increase more under RCP 8.5.
- Stream contributed more than 50% of sediment concentration by eroding stream bank.

GRAPHICAL ABSTRACT



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ABSTRACT

Climate change has a significant effect on various hydrological processes in a large river basin. The assessment of these processes is also useful for water resource management and long-term sustainability of any hydrological project. In this study, an attempt is made to quantify the effects of climate change on streamflow and sediment concentration in the Purna river basin, India. Three Regional Circulation Models (RCMs) with two Representative Concentration Pathways (RCPs) 4.5 and 8.5 for the four future periods of P1 (2009–2031), P2 (2032–2053), P3 (2054–2075) and P4 (2076–2099) are considered. Differences in scenarios are compared with the base period 1980–2005. The SWAT is used on monthly basis for the period 1980 to 2005 with calibration period 1980 to 1994 and validation period 1995 to 2005. The projected precipitation and temperature show a significant increasing trend compared to the baseline condition for both RCPs. Similarly, the average monthly streamflow is projected to increase by 24.47 to 115.94 m^3/s whereas average monthly sediment concentration by 32.58 to 162.96 mg/l under RCP 4.5 and 8.5. In particular, streamflow and sediment are expected to increase significantly from June to September at the outlet of the basin. The study results give insight into future hydrological scenarios which will be useful for policy makers to implement effective water resource strategies.

1. Introduction

The accumulation of greenhouse gases (GHG) in the environment is a major concern for global climate changes. These changes or alterations may, therefore, influence natural water resources (Arnell, 1999). According to the Intergovernmental Panel on Climate Change (IPCC) report, increase in temperature and variability of precipitation will

* Corresponding author at: Department of Civil Engineering, SGGS IE & T, Nanded, India.
E-mail addresses: nilawaraditya@sggs.ac.in (A.P. Nilawar), mlwaikar@sggs.ac.in (M.L. Waikar).

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attribute significantly to water-related risks such as flood and drought (Lindner et al., 2010). Especially, developing country like India is now facing severe climate change effects on water and agriculture sector. Therefore, the spatiotemporal response information on water resources to the climate change is important to figure out future water availability and sustainable water management plans. Gosain et al. (2006) assessed the impact of climate change on 12 Indian river basins for present and future greenhouse gas with HadRM2 climate data. The initial investigation predicted the occurrence of severe flood and drought during the 21st century.

Presently, it is of great importance to assess the influence of climate change on the regional water resources. Various factors including evapotranspiration, infiltration, and surface runoff also get affected due to climate change (Di Baldassarre et al., 2011; Joo et al., 2017). Furthermore, continuous progression in climate change may impact the water quality by altering the hydrological component. The effect of climate change on basin hydrology is normally assessed by characterizing climate change scenario to a hydrological model that is based on the futuristic greenhouse gas emission (Anand et al., 2018; Hosseini et al., 2015; Johnston and Smakhtin, 2014). Modeling streamflow is crucial for sediment concentration in the channel whereas peak streamflow rate is essential for the hydraulic structure design, flood protection and watershed management practices (Delpla et al., 2009; Routschek et al., 2014; Zhao et al., 2018). The conventional methods of measuring hydrological parameter are monotonous and time-consuming so it is desirable to use recently developed Remote Sensing (RS) and GIS-based hydrological model. Recent studies suggested that SWAT is widely used as a resourceful model to assess environmental and hydrological changes with fluctuating land type and weather conditions (Malagó et al., 2017). In addition, the output variables incorporated in the SWAT are found to address various water-related processes in the watershed (Bharati et al., 2012; Dahal et al., 2016). These models are postulated as a system based hydrological model to determine land use land cover impact and management practice on the river basin or watershed (Zhang et al., 2007). Ficklin et al. (2009) assessed the climate change impact in the highly agricultural area using the semi-distributed SWAT model in California (USA). The study results highlighted that an increase in concentration CO_2 have a remarkable effect on streamflow, evaporation and water yield. In a similar investigation, Murty et al. (2014) employed SWAT to predict water balance component in Ken basin, India. The successful application for hydrological evaluation was carried out for 25 years (1985–2009).

The IPCC defines a series of RCP scenarios (2.5, 4.5, 6 and 8.5) for future climate projection based on Coupled Model Intercomparison Project (CMIP5) (Tan et al., 2014; Van Vuuren et al., 2011). These four RCPs incorporate one alleviation scenarios priming a low driving level (RCP2.6), two stabilization scenarios (RCP4.5 and RCP6), and, one scenario with high greenhouse gas emissions (RCP8.5). These scenarios are evolved based on the driving force such as the growth of population, socio-economic development and GHG (McGuire et al., 2001; Willems and Vrac, 2011). As per the IPCC report, the global temperature may increase by 1 °C to 5 °C by the end of the century. Climate scenarios

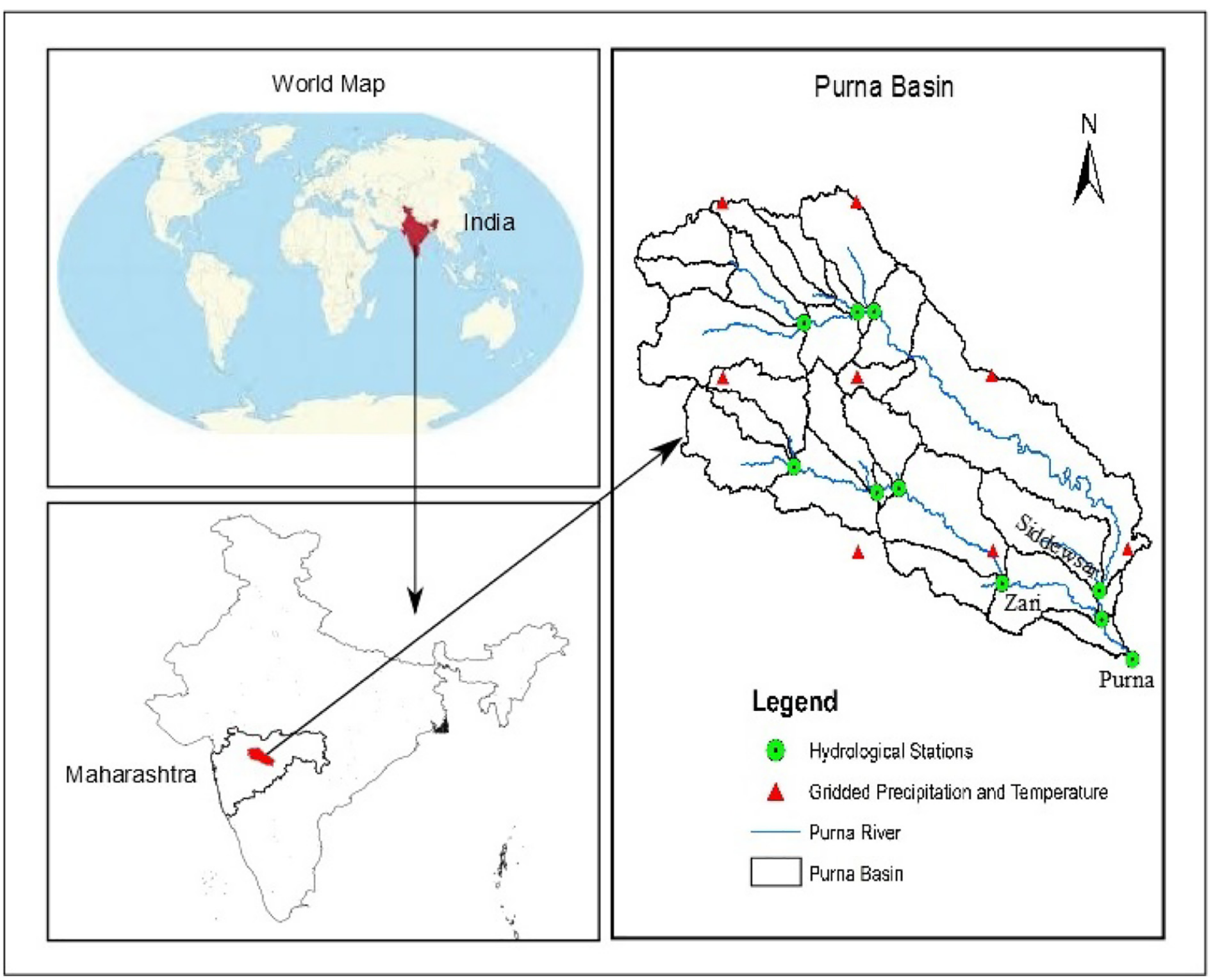

Fig. 1. Location map of Purna river basin with precipitation, temperature and hydrological station in India.