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Original Research Article

Change in rainfall erosivity in the past and future due to climate change in the central part of India

Arun Mondal*, Deepak Khare, Sananda Kundu

Department of Water Resources Development & Management, Indian Institute of Technology, Roorkee, India

A R T I C L E I N F O

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A B S T R A C T

Temporal change in rainfall erosivity varies due to the rainfall characteristic (amount, intensity, frequency, duration), which affects the conservation of soil and water. This study illustrates the variation of rainfall erosivity due to changing rainfall in the past and the future. The projected rainfall is generated by SDSM (Statistical DownScaling Model) after calibration and validation using two GCMs (general circulation model) data of HadCM3 (A2 and B2 scenario) and CGCM3 (A1B and A2 scenario). The selected study area is mainly a cultivable area with an agricultural based economy. This economy depends on rainfall and is located in a part of the Narmada river basin in central India. Nine rainfall locations are selected that are distributed throughout the study area and surrounding. The results indicate gradually increasing projected rainfall while the past rainfall has shown a declined pattern by Mann–Kendall test with statistical 95% confidence level. Rainfall erosivity has increased due to the projected increase in the future rainfall (2080 s) in comparison to the past. Rainfall erosivity varies from −32.91% to 24.12% in the 2020s, −18.82 to 75.48% in 2050 s and 20.95–202.40% in 2080s. The outputs of this paper can be helpful for the decision makers to manage the soil water conservation in this study area.

1. Introduction

Rainfall kinetic energy or rainfall erosivity (R factor) is an important parameter of soil erosion by water, which is directly related to climatic parameter of rainfall (Lobo, Frankenberger, Flanagan, & Bonilla, 2015; Rosewell, 1986). Rainfall erosivity has a capability to detach soil particles by rainfall (van Dijk, Bruijnzeel, & Rosewell, 2002). This relationship was proposed by Govers (1991); Hudson (1961) and was used in Revised Universal Soil Loss Equation (RUSLE) model to estimate soil erosion (Renard, Foster, Weesies, McCool & Yoder, 1997). Rainfall and erosivity are not a linear relation to soil erosion, which mainly depends on the size of raindrops, intensity and duration of effective rain (Salles, Poesen, & Sempere-Torres, 2002). Erosivity may increase after high rainfall intensities to create saturation and ponding, which will increase the detachment capacity of the soil (Salles, Poesen, & Sempere-Torres, 2002). Nature of rainfall depends on the variation of intensity, amount, duration, frequency of rain which may occur due to climate change impact. Panagos et al. (2015), have used the R factor of RUSLE to ass ess the rainfall erosivity of Europe. Nearing et al. (2005) also indicated a change in the runoff and soil erosion due to changed precipitation. Rainfall erosivity is an important factor as rainfall or precipitation is considered as the main driving force of soil erosion and has direct influence on the soil particle detachment and transport of the eroded particles by runoff (Wischmeier & Smith, 1978).

Various parameters of climatic variables are used to detect the trend analysis using past historical climatic data by various statistical methods (Kumar & Jain, 2010; Kumar, Jain, & Singh, 2010; Kundu, Khare, Mondal, & Mishra, 2014; Kundu, Khare, Mondal, & Mishra, 2015; Mondal, Khare, & Kundu, 2015; Pal & Al-Tabbaa, 2010; Sonali & Kumar, 2013; Subash, Singh, & Priya, 2013; Tabari, Talaee, Ezani, & Some'e, 2012; Wang et al., 2013; Yue & Hashino, 2003;). Different types of GCM (General Circulation Model) data are used for predicting the future rainfall and temperature (Anandhi, Srinivas, Nanjundiah, & Nagesh Kumar, 2008; Chen, Xu, & Guo, 2012; Chu, Xia, Xu, & Singh, 2010; Hassan, Shamsudin, & Harun, 2014; Mondal et al., 2014; Raje & Mujumdar, 2011; Yang, Li, Wang, Xu, & Yu, 2012). GCM data are not used directly in the hydrological model at local level study due to coarse resolution of the data. Different types of methods are used to downscale into local level using coarse resolution GCM data (Carter & Kenkyū, 1994). For climate downscaling study, different established methods are, Artificial Neural Networks (ANN), Multiple Linear Regression (MLR), Support Vector Machine (SVM) (Duhan & Pandey, 2015;

* Corresponding author.
E-mail addresses: arun.iirs@gmail.com (A. Mondal), kharefwt@gmail.com (D. Khare), sanandakundu@gmail.com (S. Kundu).
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Hassan et al., 2014; Raje & Mujumdar, 2011) etc. Rainfall or precipitation and temperature estimation studies have been carried out by researchers using GCMs data with the help of various methods in India (Rupa Anandhi et al., 2008; Goyal & Ojha, 2012; Kumar et al., 2006; Meenu, Rehana, & Mujumdar, 2013; Mondal et al., 2014; Vigaud, Vrac, & Caballero, 2013).

Climate change effects can change the rainfall pattern (amount, intensity, frequency, duration) of a study area. Rainfall erosivity can increase due to increased rainfall which may increase the power to detach and carry soil particles. Yang, Kanae, Oki, Koike, and Musiake (2003) has studied the change in soil erosion due to future climate change (2090) for the entire globe and the result has shown an increase of around 9%. A related study of only rainfall erosivity has been done by various researchers in different parts of the world (García-Ruiz et al., 2015; Haregeweyn et al., 2013; Teng et al., 2016; Wen, Zheng, Shen, Bian, & Jiang, 2015; Zhao, Mu, Wen, Wang, & Gao, 2013). Rainfall erosivity is considered as an input parameter of soil erosion in Indian condition by many researchers (Biswas & Pani 2015; Dabral, Baithuri, & Pandey, 2008; Dutta, Das, Kundu, & Taj, 2015; Jain, Kumar, & Varghese, 2001; Khare, Mondal, Kundu, & Mishra, 2016; Mondal et al., 2014; Mondal et al., 2014; Mondal et al., 2016; Mondal, Khare, and Kundu, 2016a; Mondel et al., 2016b; Narayana & Babu 1983; Pal, 2016; Pandey, Mathur, Mishra, & Mal, 2009; Patel & Kathwas, 2012; Prasannakumar, Vijith, Abinod, & Geetha, 2012; Raymo & Ruddiman, 1992).

Climate change can change the rainfall erosivity due to alteration of rainfall. In the future, variation of rainfall erosivity has been calculated from changing rainfall, which is computed from GCM data. The study of change in rainfall erosivity due to climate effects is lacking. Recently few studies have been carried out in different parts of the world. But in the Indian context, this type of study will be an important work in the future.

The major objective of the study is the assessment of potential changes of rainfall erosivity due to change in rainfall because of the effects of climate change in the past and the future. Future estimation of rainfall has been carried out by the SDSM (Statistical DownScaling Model) method using HadCM3 (A2 and B2 scenario) and CGCM3 (A1B and A2 scenario) GCMs data. The change in the rainfall erosivity in the future has been generated and compared using predicted rainfall from different GCM scenarios. In India, this type of study is a challenging work which will be helpful for the particular study area for soil conservation, dam design and construction, agricultural management, etc.

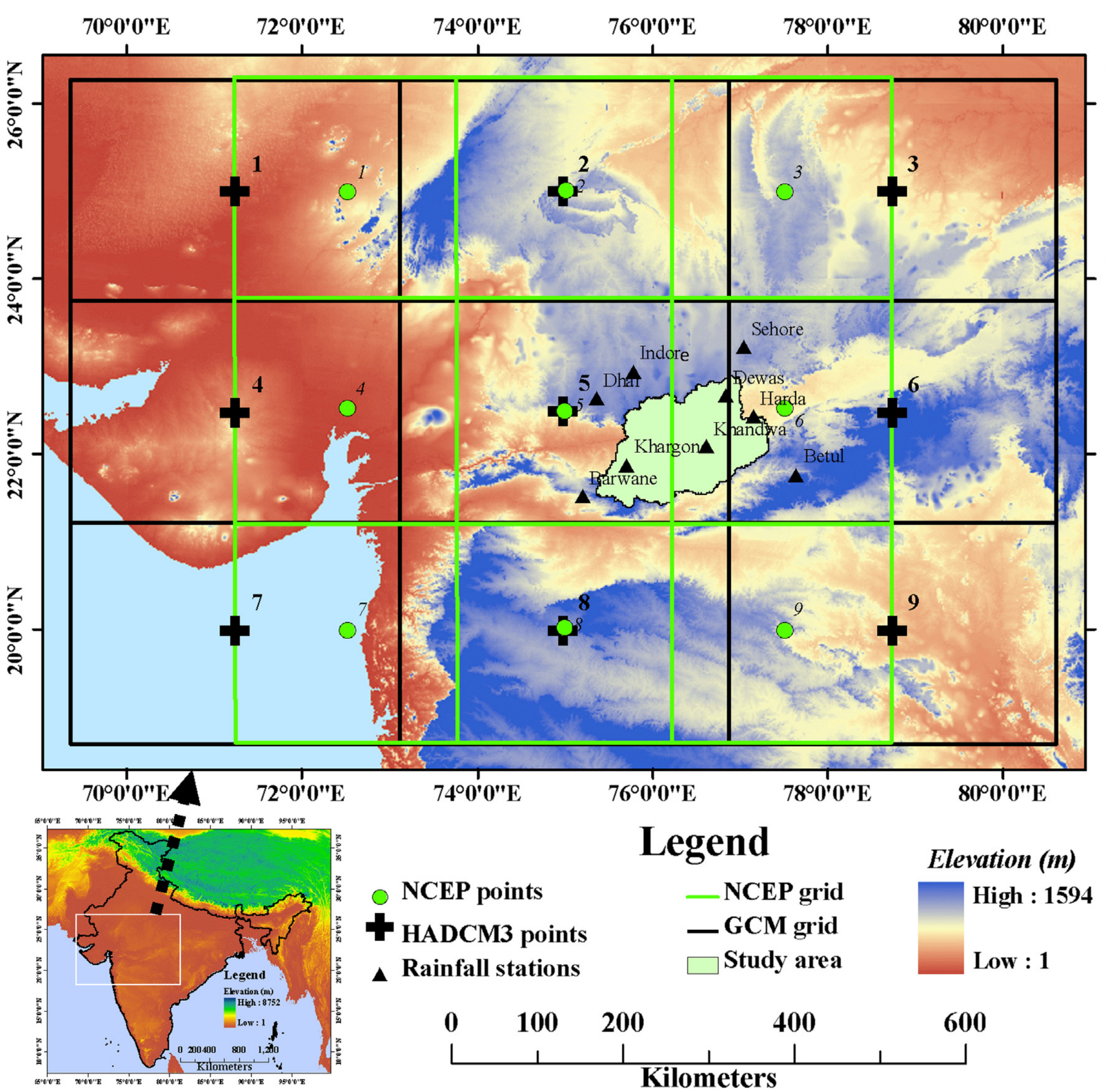

Fig. 1. Study area (Location points of 9 stations with NCEP and GCM grids).