Chapter 5
Development of Rainfall Prediction Models Using Machine Learning Approaches for Different Agro-Climatic Zones

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ABSTRACT

This study focuses on modelling the changes in rainfall patterns in different agro-climatic zones due to climate change through statistical downscaling of large-scale climate variables using machine learning approaches. Potential of three machine learning algorithms, multilayer artificial neural network (MLANN), radial basis function neural network (RBFNN), and least square support vector machine (LS-SVM) have been investigated. The large-scale climate variable are obtained from National Centre for Environmental Prediction (NCEP) reanalysis product and used as predictors for model development. Proposed machine learning models are applied to generate projected time series of rainfall for the period 2021-2050 using the Hadley Centre coupled model (HadCM3) B2 emission scenario data as predictors. An increasing trend in anticipated rainfall is observed during 2021-2050 in all the ACZs of Chhattisgarh State. Among the machine learning models, RBFNN found as more feasible technique for modeling of monthly rainfall in this region.

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INTRODUCTION

Climate comprises a general pattern of weather conditions, seasons and weather extremes like drought, flood, heat wave and cold wave situations. Climate study is a very complicated phenomenon which contains various climatic variables, and their behaviors are also different. Climate of any region varies with space and time on account of various atmospheric forcing. Long-term systematic changes of statistical properties of the climate variables are referred to as "climate change". The statistical distribution of weather patterns with a particular long-term or extended period (decades or longer time span) indicates the climate change (Yang et al. 2010; 2015; 2017; Shi et al. 2016). In another word, climate change also refers to a shift in climate from its average weather condition eventually for the long-term period. According to United Nations Framework Convention on Climate Change (UNFCCC), climate change is directly or indirectly associated with human interventions, which alter the composition of atmospheric balance (IPCC, 2007). However, it may be caused by a hydrological cycle imbalance, phytochemical effects, biotic manners, variation in solar radiations, geological inequality, volcanic eruptions, anthropogenic activities, etc. During the recent past, the intervention of anthropogenic activities such as urbanization, population growth, industrialization, deforestation, settlements, burning of fossil fuels, etc., has increased the greenhouse gases (GHG) emission (Kumar and Sharma, 2017). Intergovernmental Panel on Climate Change (IPCC, 1996) reported that global warming is mainly due to the enhanced GHG radiation and is likely to have a significant impact on the hydrological cycle and future climate change. Alarming effects of climate change viz. severe floods, droughts and other extreme hydrological events catch the attention of the entire world to think and assess its future impact on global climate. In the recent past, various severities of adverse climatic events have been identified. Climate change seems to be more pronounced, if assessed at local and regional scale compared to global scale because globally its effects are more generalized.

In an agrarian country like India, uneven rainfall distribution may disrupt food availability and results in reduced agricultural productivity. Hence, precise knowledge about the past, present and future rainfall pattern over a region can play an important role in planning cropping pattern, finalizing the schedule of the farm operation and designing irrigation structures for effective utilization of available water resources for enhancing the agricultural production. Hence, in order to assess the climate change impacts on rainfall distribution and its future trends, the present investigation is carried out using long term monthly rainfall time series to develop an appropriate technique for the rainfall modeling in the three distinct Agro-climatic Zones (ACZs) viz., Chhattisgarh Plains, Bastar Plateau and Northern Hills ACZs of Chhattisgarh state in east central India.

In a recent decade study about possible changes in rainfall pattern over a region due to climate change is being assessed using statistical downscaling of general circulation models (GCM) products from global to local scale. Statistical downscaling methodologies are based on transfer functions, which highlight relationships between global scale predictors and local scale response variable using linear/non-linear regression equations (Wilby et al. 2002, 2004; Murphy and Timbal, 2008). GCM products provide the required the long period global scale data of various large scale climate variables, which is used as predictors for rainfall prediction. Multi-linear regression (MLR), principal component analysis (PCA) and canonical correlation analysis (CCA) are outdated statistical downscaling regression methods (Dibike and Coulibaly, 2005). Conversely, machine learning techniques such as artificial neural network (ANN), least square support vector machine (LS-SVM) and least square support vector regression (LS-SVR) are gaining popularity during the past two decades and considered under nonlinear regression models. Among