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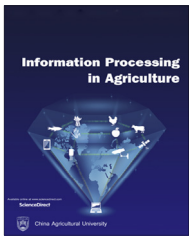

Temperature based generalized wavelet-neural network models to estimate evapotranspiration in India

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ABSTRACT

In this paper, generalized wavelet-neural network (WNN) based models were developed for estimating reference evapotranspiration (ET_o) corresponding to Hargreaves (HG) method for different agro-ecological regions (AERs): semi-arid, arid, sub-humid, and humid in India. The input and target to the WNN models are climate data (minimum and maximum air temperature) and ET_o (estimated from FAO-56 Penman Monteith method), respectively. The developed WNN models were compared with the various generalized conventional models such as artificial neural networks (ANN), linear regression (LR), wavelet regression (WR), and HG method to test the best performed model. The performance indices used for the comparison include root mean squared error (RMSE), Nash-Sutcliffe efficiency (NSE), the ratio of average output to the average target ET_o values (R_{ratio}), and relative percentage (RP). The WNN and ANN models were performed better as compared to LR, WR and HG methods. Further, the best performed WNN and ANN models were tested on locations, which were not included in training to test their generalizing capability. It is concluded that the WNN and ANN models were shown good generalizing capability for the tested locations as compared to HG method.

1. Introduction

Accurate estimation of reference evapotranspiration (ET_o) is needed for irrigation scheduling, water resources management, crop yield assessment and hydrological modeling as it is one of the significant components of the hydrologic cycle. To overcome the limitations of existing ET_o methods (direct and indirect), researchers are widely developing the artificial neural network (ANN) based in ET_o models [2–4]. These ANNs have the capability to model the complex non-linear relationship between the air temperature, solar radiation and ET_o. The climate data that needed for accurate estimation of ET_o might cope with non-stationarity. A wavelet transformation (WT) serves as an effective tool for accurately modeling ET_o using various non-stationary hydro-climatic variables by locating the irregular spatial and temporal distributed multi-scale features of data [13]. A number of studies were reported in the literature over the years, on the application of wavelet neural networks (WNNs; combination of ANNs and WT) for modeling different hydro-climatic variables, especially ET_o [1,5,6,9–11,14,15].

The WNN model developed for trained location might be useful only in the developed location unless the external gen-

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eralizing capability is evaluated, which is not done in most of the studies. If these WNN models are only accurate for the training locations, their real applicability is limited to new locations data, which were not trained. Hence, there is a need to develop generalized WNN (WNN) models which are not only applicable for model training locations but also for outside the training locations. This can be achieved by considering the pooled data of various locations, which have the properties of both spatial and altitudinal variations during training [2–4]. Further, in a developing country like India with higher spatial variation in climate, the required climatic data for ET_o estimation may be extremely hard to obtain at all locations due to the difficulty in observation. The most readily available data for India may be the maximum air temperature (T_{max}) and minimum air temperature (T_{min}). This shows the need of developing WNN models with limited input data i.e. corresponding to Hargreaves (HG) method. Therefore, this study aims: (i) to develop the generalized WNN models corresponding to HG method for four agro-ecological regions (AERs: semi-arid, arid, sub-humid, and humid) of India, (ii) to test the generalizing capability of WNN models with the model development and model testing locations, and (iii) to compare the developed WNN models with the generalized ANN (ANN), generalized linear regression (LR), generalized wavelet regression (WR), and conventional HG method.

2. Study area and climate data

The study area consists a total of 25 different meteorological locations in India (Fig. 1). The data sample consists of daily climate data of T_{min}, T_{max}, and extra terrestrial radiation (R_a). Due to the unavailability of measured lysimeter ET_o data for the selected study locations, it was estimated by the FAO-56 PM method [16]. The classification of climates (AERs) for dif-

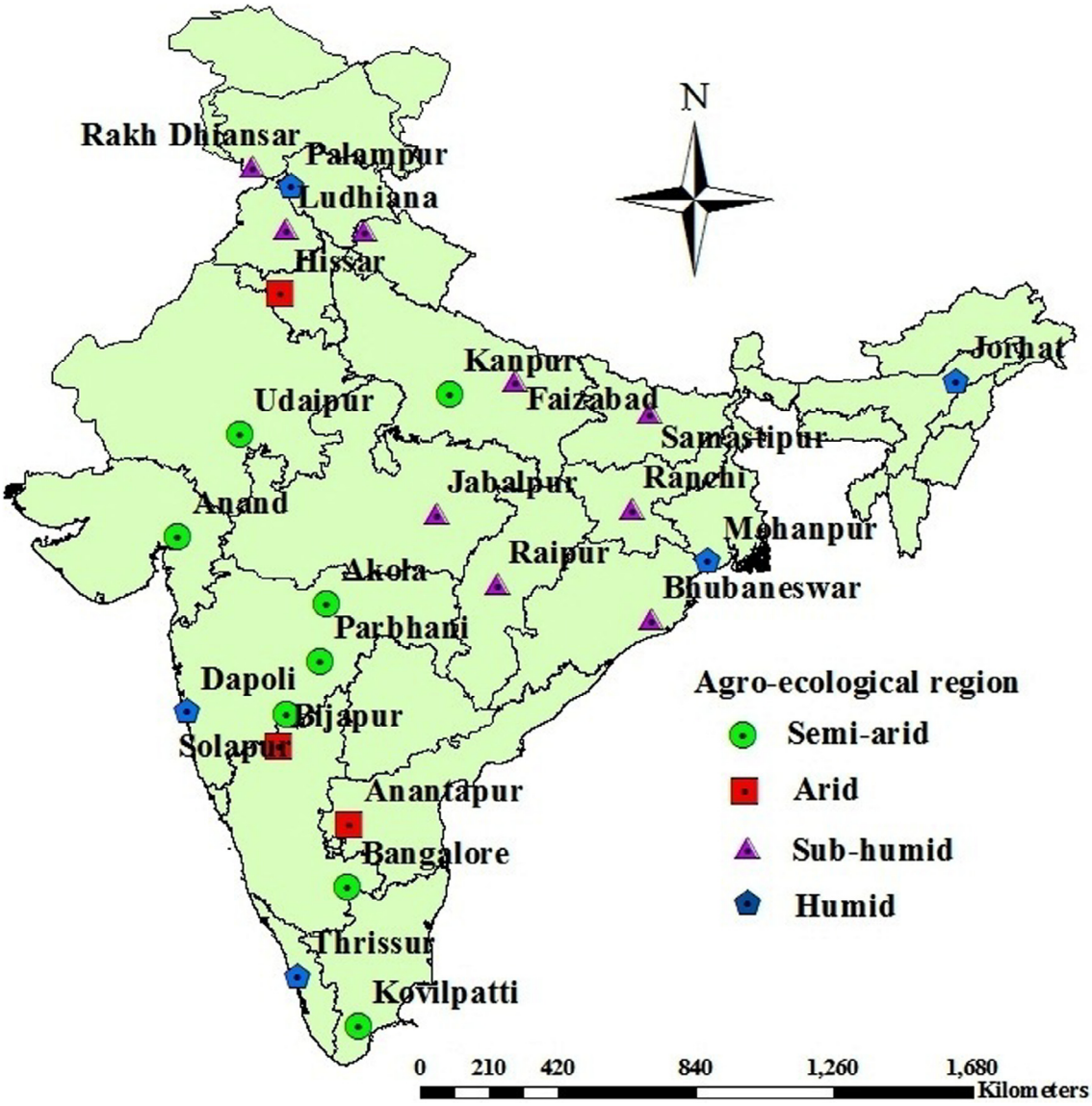

Fig. 1 – Study area (25 climatic stations and four agro-ecological regions).

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