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Rainfall Prediction Using Artificial Neural Network (ANN) for *tarai* Region of Uttarakhand

Pooja Yadav[1] and Atish Sagar[2*]

[1]Department of Irrigation and Drainage Engineering, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India.
[2]Division of Agricultural Engineering at Indian Agricultural Research Institute, New Delhi, India.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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Short Research Article

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ABSTRACT

Rainfall prediction is clearly of great importance for any country. One would like to make long term prediction, i.e. predict total monsoon rainfall a few weeks or months and in advance short term prediction, i.e. predict rainfall over different locations a few days in advance [1]. Predicted by using its correlation with observed parameter. Several regression and neural network based models are currently available. While Artificial Neural Network provide a great deal of promise, they also embody much uncertainty [2,3]. In this paper, different artificial neural network models have been created for the rainfall prediction of Uttarakhand region in India. These ANN models were created using training algorithms namely, feed-forward back propagation algorithm [4,5]. The number of neurons for all the models was kept at 10. The mean squared error was measured for each model and the best accuracy was obtained by the feed-forward back propagation algorithm with MSE value as low as 0.00547823.

Keywords: Total monsoon rainfall; feed-forward back propagation algorithm; neurons; training algorithms; Artificial Neural Network.

**Corresponding author: E-mail: atishmicky.sagar@gmail.com;*

1. INTRODUCTION

Weather forecasting is one of the most imperative and demanding operational responsibilities carried out by meteorological services all over the world. It is a complicated procedure that includes numerous specialized fields of knowhow. The task is complicated because in the field of meteorology all decisions are to be taken in the visage of uncertainty. Different scientists over the globe have developed stochastic weather models which are based on random number of generators whose output resembles the weather data to which they have been fit [6]. The reason is that ANN (Artificial Neural Network) model is based on 'prediction' by smartly 'analyzing' the trend from an already existing voluminous historical set of data. Apart from ANN, the other models are either mathematical or statistical. These models have been found to be very accurate in calculation, but not in prediction as they cannot adapt to the irregularly varying patterns of data which can neither be written in form of a function, nor deduced from a formula.

Amongst all weather happenings, rainfall plays the most imperative part in human life. Human civilization to a great extent depends upon its frequency and amount to various scales. Several stochastic models have been attempted to forecast the occurrence of rainfall, to investigate its seasonal variability, to forecast yearly/monthly rainfall over some geographical area Recent research [7] activities in artificial neural network have shown that ANNs have powerful pattern classification and pattern recognition capacity. Inspired by biological systems, particularly by research into the human brain, ANNs are able to learn from and generalize from experience. Currently, ANNs are being used for a wide variety of tasks in many different fields of business, industry and science.

ANNs are data-driven self-adaptive methods in that there are few a priori assumptions about the models for problems under the study.

- This modeling approach with the ability to learn from experience is very useful for many practical problems since it is often easier to have data than to have good theoretical guesses about the underlying laws governing the systems from which data are generated. It nevertheless provides a practical and, in some situations, the only feasible way to solve real-world problems.
- ANNs can generalize. After learning the data presented to them (a sample), ANNs can often correctly infer the unseen part of a population even if the sample data contain noisy information. As forecasting is performed via prediction of future behavior from examples of past behavior, it is an ideal application area for neural networks, at least in principle [8].
- ANNs are universal functional approx. imators. It has been shown that a network can approximate any continuous function to any desired accuracy. ANNs have more general and flexible functional forms than the traditional statistical methods can effectively deal with. Any forecasting model assumes that there exists an underlying relationship between the inputs and the outputs. traditional statistical forecasting models have limitations in estimating this underlying function due to the complexity of the real system [9]. ANNs can be a good alternative method to identify this function.

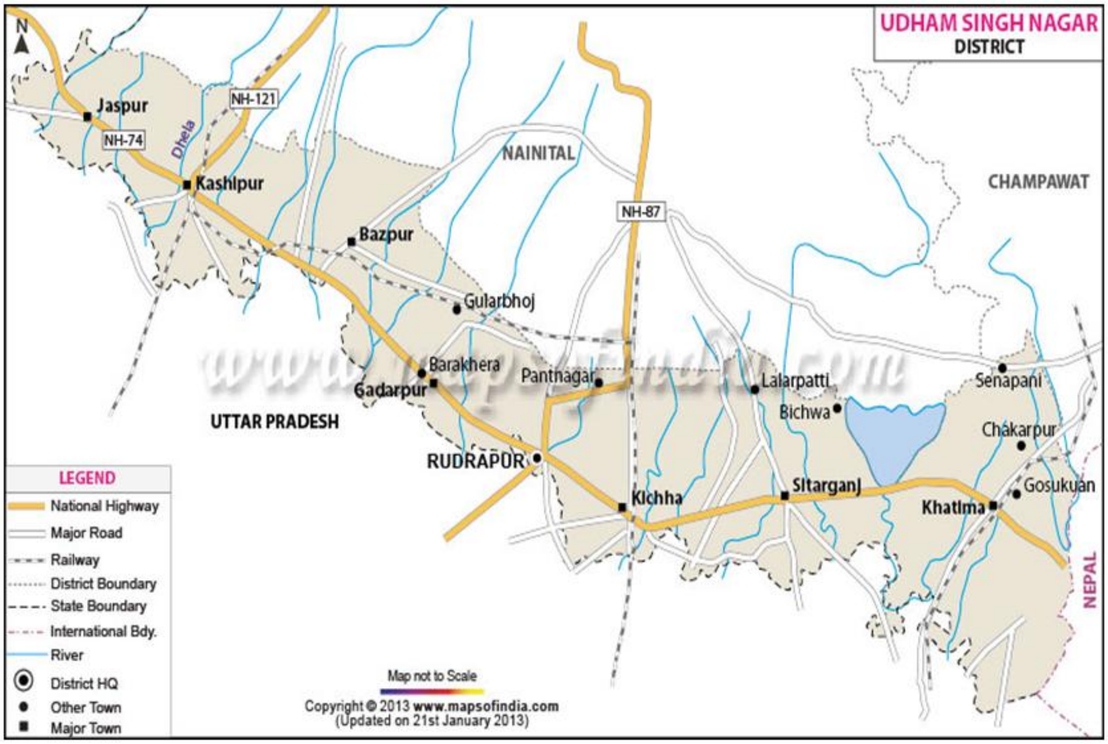
Finally, from the above discussion it could be said that ANNs are nonlinear [10]. Forecasting has long been the domain of linear statistics [11]. In this paper, artificial neural networks have been used to create different models which predict the weekly rainfall of Uttarakhand, region in India. The input data set comprises of parameters affecting rainfall such as minimum temperature, maximum temperature,minimum humidity, maximum humidity and wind speed. The results obtained from all the models were then compared to each other using the Mean Square Error (MSE) and sub sequentially the conclusions were drawn.

2. MATERIALS AND METHODS

The methodology consists of following part of contents;

2.1 Study Area

The research work endeavor to develop an ANN model to forecast average weekly rainfall in the Udham Singh Nagar district of Uttarakhand state. It lies within the geographical co-ordinates of latitude 29°3' 0" N and longitudes of 79°31' 0" E. Weather data were obtained from Crop Research Center, G.B.P U A & T (Govind Ballabh Pant University of Agriculture And Technology) Pantnagar, Udham Singh Nagar District, Uttarakhand, India.



Map 1. Showing Udham Singh Nagar District, Uttarakhand, India

2.2 Data Collection

For this study, five different parameters which are related with rainfall of a region were taken. These five parameters were minimum temperature, maximum temperature, minimum humidity, maximum humidity and wind speed. A dataset of 2430 data was collected which extended from 1970 to 2016. For the training purposes 1823 samples were taken while validation and testing phase had 607 samples each. The input data sample for training was thus 5x1823 matrixes while the output layer data was 1x607matrix.

Armesh and Negaresh, [12] have proved that there are significant large scale correlations between the minimum & maximum temperature and the rainfall for North America and Europe [20]. This relation was globally expanded by Trenberth and Shea in 2005.

2.3 Normalization

The data collected for input layer were different in units and had no correlation among them. Therefore, to solve this problem, min-max normalization was used to limit the data values between 0 and 1. According to the min-max normalization, each value was normalized using following equation:

$$\text{Normalized } (e_i) = \frac{ei - emin}{emax - emin}$$

There were 4 different ANN models which were trained and tested using different combinations of the training functions and adaptive learning functions. The training algorithms used in these models was feed forward back propagation algorithm. The training functions used were TRAINLM and TRAINRP while the adaptive learning functions were TRAINGD and TRAINGDM.

Table 1. Analogy between biological and artificial neural networks

Biological network	Artificial Neural Network
Soma	Neuron
Dendrite	Input
Axon	Output
Synapse	Weight

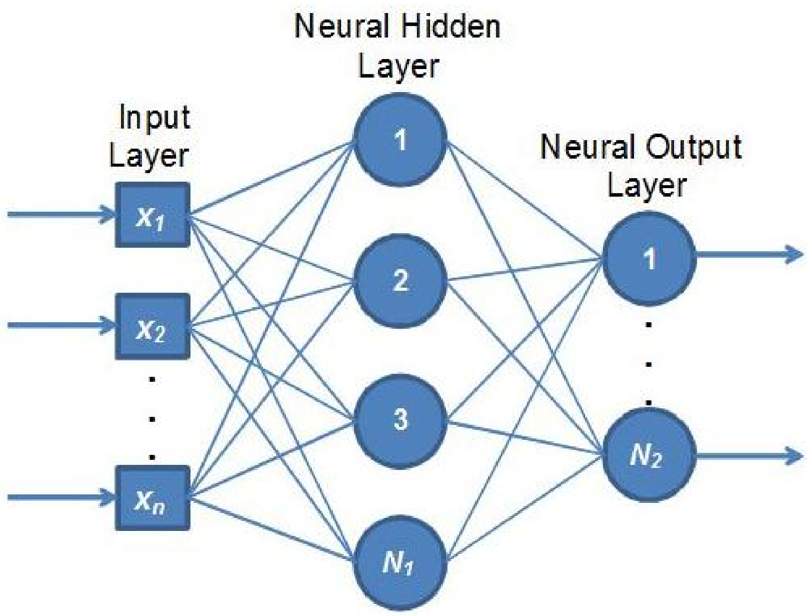


Fig. 1. General architecture of Artificial Neural Network

Table 2. Training variables and their assigned values for ANN models

Training variables	Assigned values
Type of neural network	feed forward back propagation algorithm
Number of input	5
Number of hidden layers	1
Number of neurons in hidden layer	10
Total number of layers	2
Training function	TRAINRP, TRAINLM
Transfer function in hidden layer	Logsigmiod
Transfer function in output layer	Purelin
Maximum number of epochs	1000

3. RESULTS, DISCUSSION AND FUTURE WORKS

The artificial neural network models were trained using the input data. There were total 4 ANN models which were trained using the 1823 data samples of the region which were collected over 37 years (1970 – 2016). After the training, the validation and testing of the neural networks were done using 607 data samples each. The performance measure of the neural networks was the Mean Square Error (MSE). For a network to be more accurate, the MSE has to be as low as possible. While training and testing the neural networks using the feed forward back propagation algorithm, the minimum MSE obtained was 0.00547823 which occurred when the training function was TRAINLM and the adaptive learning function was LEARNGDM. When the neural networks were trained using the feed forward back propagation algorithm, the minimum MSE obtained was 0.010765 which was obtained when the training function was TRAINRP and the adaptive learning function is LEARNGDM. The details and the performance of each neural model under study has been summarized in the Table 3. From the table, it can be deduced that the best performance was delivered by the neural networks which were trained by the feed forward back propagation algorithm in which the training function was TRAINLM and the adaptive learning function was LEARNGDM the MSE ranged from 0.00547823 to 0.010077.

Table 3. Artificial Neural Network models and their performance

Model	Training algorithm	Training function	Adaptive learning function	MSE
Model 1	Feed forward back propagation	TRAINLM	LEARNGDM	0.005478
Model 2	Feed forward back propagation	TRAINRP	LEARNGD	0.010765
Model 3	Feed forward backpropagation	TRAINRP	LEARNGD	0.011748
Model 4	Feed forward back propagation	TRAINLM	LEARNGDM	0.010077

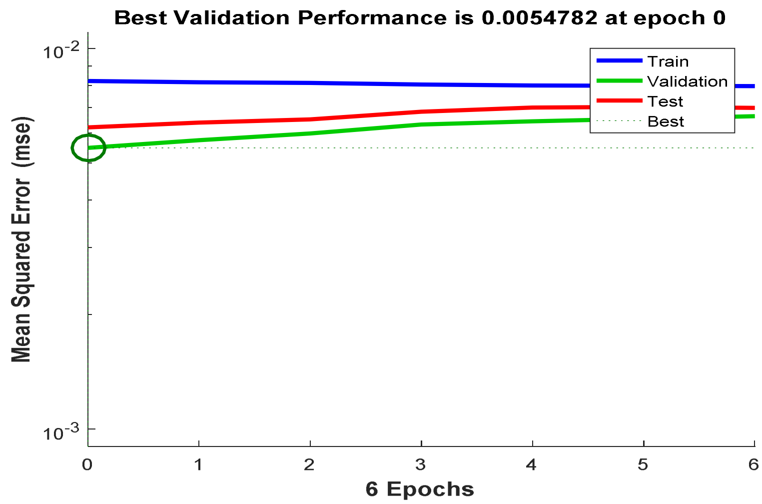


Fig 2. The feed forward back propagation algorithm with training function was TRAINRP and the adaptive learning function is LEARNGD the MSE is 0.00547823 (Model 1)

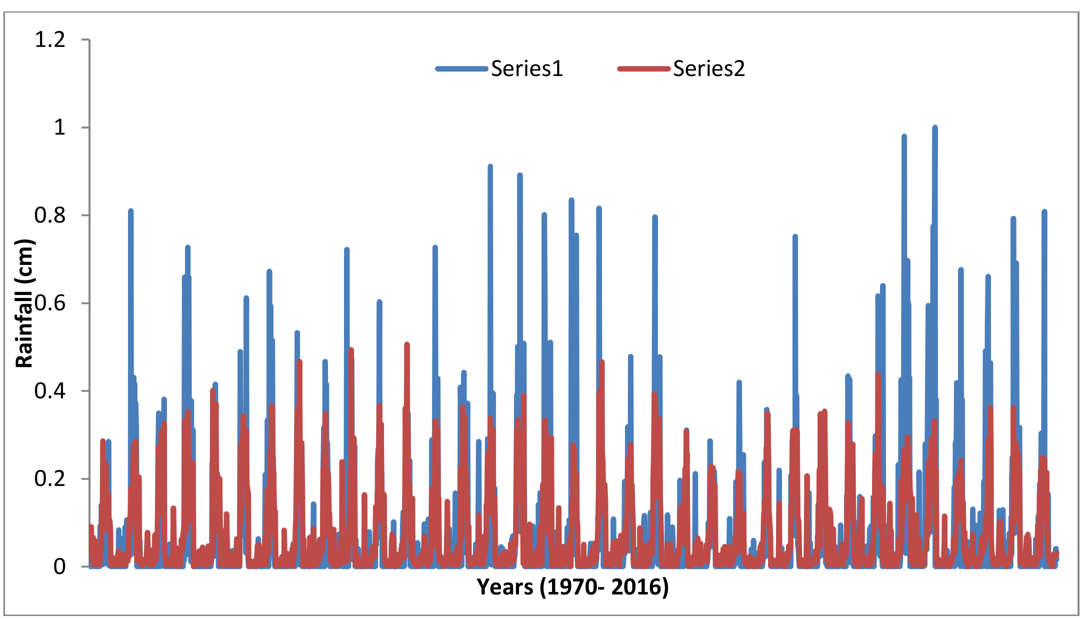


Fig 3. Comparison between actual (series 1) and predicted (series 2) data by Model 1

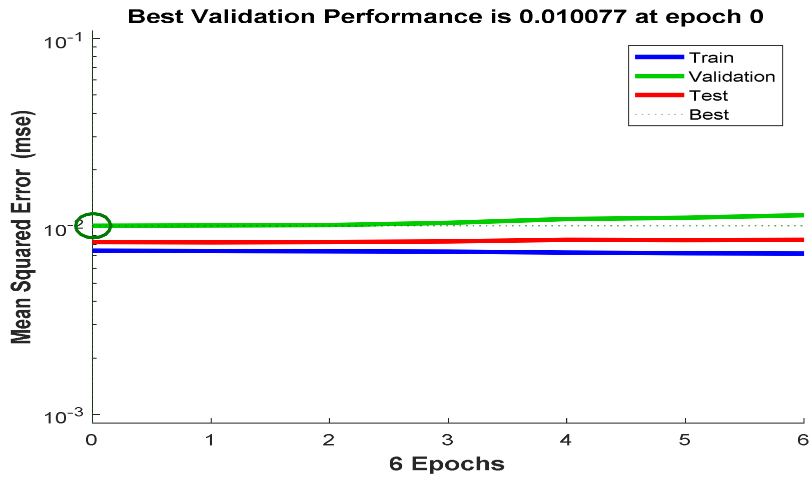


Fig 4. Feed forward back propagation algorithm with training function was TRAINLM and the adaptive learning function is LEARNGDM the MSE is 0.010077 (Model 4)

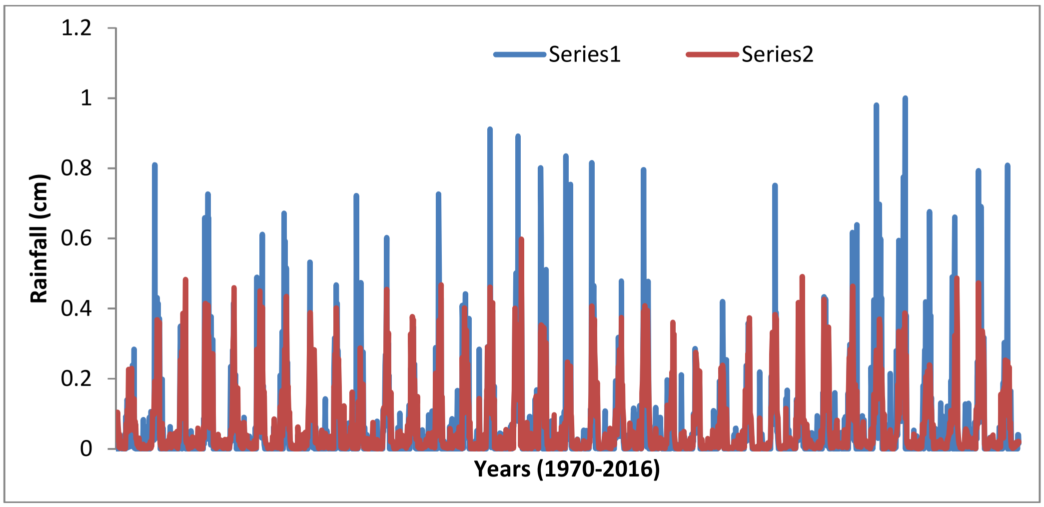


Fig 5. Comparison between actual (series1) and predicted (series2) data by model 4

The Fig. 2 and Fig. 4 reveals that the performance of the model 1 and 4 were best during the training. These figures also showed the comparative charts of the actual rainfall that occurred during the given span of time and the predicted rainfall by the best performing neural networks. Model 1, whose MSE was 0.00547823 has the best accuracy which is evident in the Fig. 2 where the two lines (actual rainfall and predicted rainfall) are almost on the same trend and values most of the time.

Further following works could be done;

- The network models which have been used in this research paper can be effectively used for the prediction of the missing values of rainfall at any given place.
- Moreover, this research work can also be extended to predict the short term rainfall at a region which can help the rain crop harvesting the flood management system in the country.

4. CONCLUSION

From the experimental study the following observation were made;

- LEARNGDM is the best learning function to train your data with.
- LEARNGD is a bit time consuming.
- TRAINLM is the best training function.

- Multi-layer Algorithm is better than Single-layer algorithm terms of performance.
- NNTOOLS should be used to implement the prediction algorithms as a it gives an option of implementing algorithms.
- The input /output data should be normalized if they are of very high order

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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