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Application of Soft Computing Technique on Crop Yield Prediction in Agriculture Enforcement

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ABSTRACT: Soft computing techniques have become popular in the field of agriculture to predict crop yields and improve crop management. In this study, various soft computing techniques have been applied to determine the crop information using Geospatial Data using MATLAB software. It is determined using the Artificial Neural Network (ANN) with the feed-forward backpropagation network (FFBP). The input data considered for the ANN Modeling is the Temperature, Precipitation and Area for the simulation of the Production. The optimal ANN structure's Root Means Square Error (RMSE), Nash-Sutcliffe Efficiency (NSE), Scatter Index (SI), and Correlation Coefficient (CC) were considered.

KEYWORDS: Artificial Neural Network, Geospatial Data, Crop Information, Climate Data, Soft Computing.

I. INTRODUCTION

Rainfall and temperature are two of the most important climatic drivers of vegetative development, and differences in both can restrict a crop's growth phases and hence reduce agricultural yield. Until recently, much of the research relied on changes in the mean value of climatic variables to determine the influence of climate change on agricultural production. Precipitation is regarded as the most vital component in this context. However, other climatic factors, such as Vapour Pressure and exposure to severe temperatures throughout particular stages of crop growth, capture parts of climate variability.

Agriculture accounts for more than 74% of total land utilization in districts such as Bidar, Bijapur, Gulbarga, Raichur, Dharwad, and Belgaum. Less land is utilized for agriculture in the malnad districts of Uttara Kannada, Kodagu, Shivamogga, Chikkamagaluru, and Dakshina Kannada.

The main crops grown in Koppal region include paddy, maize, jowar, cotton, and groundnuts. Rice is one of the primary crops grown in the region, with both irrigated and rain-fed cultivation being practiced. Maize and jowar are also widely cultivated in Koppal, and are used both for human consumption and as animal feed. Cotton is another major crop, with Koppal being one of the largest cotton producing districts in Karnataka. Groundnuts are also widely cultivated in the region, and are an important source of income for many farmers.

II. TECHNIQUES OF SOFT COMPUTING

A. Soft Computing:

Soft that develops taxonomies to run each little element is a degree of similarity for all classes. It provides more illuminating graphics and potentially exact results, particularly for data classifications with unequal three-dimensional resolution. Artificial Neural Networks, pattern recognition, Fuzzy Logic, Genetic Algorithms, Decision Trees, and other Soft Classification Methods are examples.

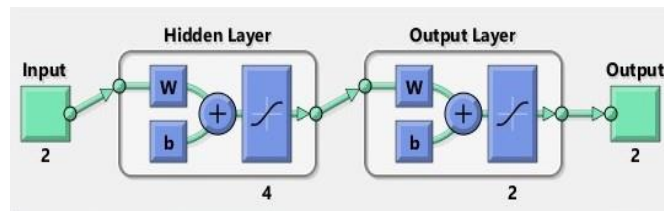
B. ANN model development:

Artificial neural networks (ANNs) are data-processing algorithms based on biological brain systems that are used to solve a wide range of scientific and technical issues, particularly in areas where standard modelling approaches fail. One input

layer, one or more hidden layers, and one output layer make up the network design, with multiple neurons in each layer transporting data from the input layer to the hidden layers and from the hidden layers to the output layer.

One of the most often utilized methods in ANN models is the backpropagation technique. Algorithms for back-propagation training Two of the most important variants of this method are gradient descent and gradient descent with momentum. Because consistent learning demands low learning rates, these algorithms are extremely sluggish. The Levenberg–Marquardt (LM) method is a more expedient method that employs standard numerical optimization techniques to address some of the previous flaws.

In an ANN model, the number of hidden layers, the number of neurons in each layer, the training approach, and the kind of transfer function should all be modified. The transfer function specifies the relationship between a neuron's inputs and outputs, as well as the network's inputs and outputs.



III. MATERIALS AND METHODS

A. Data Collection:

The dataset utilized in this investigation came from Google Earth Interface- Climatic Research Unit Time-Series (CRUTS) version 4.05 for Meteorological Data and Agricultural Data was obtained from the Crop production statistics information system website [https://aps.dac.gov.in/APY/Public_Report1.aspx]. The data was all in pdf format, which was subsequently converted to excel format using a variety of tools and procedures. To manage missing numbers, noise, and outliers, extensive pre-processing was necessary. We pre-processed and choose just the variables necessary for our research from the dataset: Temperature and

Precipitation of the Koppal districts, as well as the cultivated area for each crop, analysed using the requirements. Following the necessary dataset formats and pre-processing, the final version of our data comprises Kharif Season (July–October) data sets from 2007 to 2017.

B. Input Variables

We chose a small number of critical input factors that have the greatest impact on agricultural output from the large original dataset. For the years 2009 to 2018, all inputs were examined.

1) The environmental factors:

a) Precipitation: The average annual precipitation in the Belgaum district was derived by averaging the monthly rainfall (mm). Typically, the year with the most average rainfall produces the most agricultural output.

b) Temperature: Temperature variations throughout the year have a major influence on agricultural yield for that year. As a result, we incorporate the Kharif season's average temperature in our research.

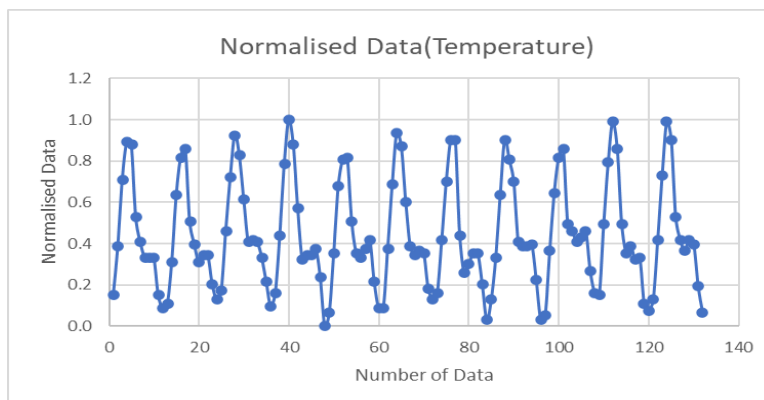
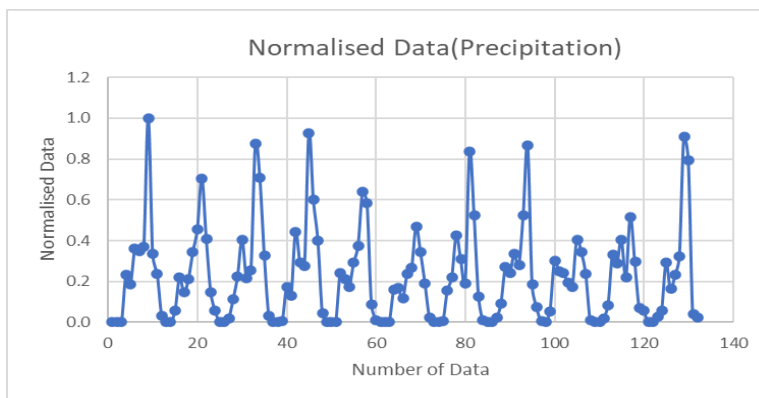
IV. METHODOLOGY

A. Step 1. Normalisation of Data

The input data set, which incorporates meteorological data from geographical data such as vapor pressure, precipitation, diurnal temperature range, and temperature, and agricultural data which includes production and yield, is normalized using the following equation so that data ranges between 0 and 1 and fed into MATLAB for soft computing.

Equation 1

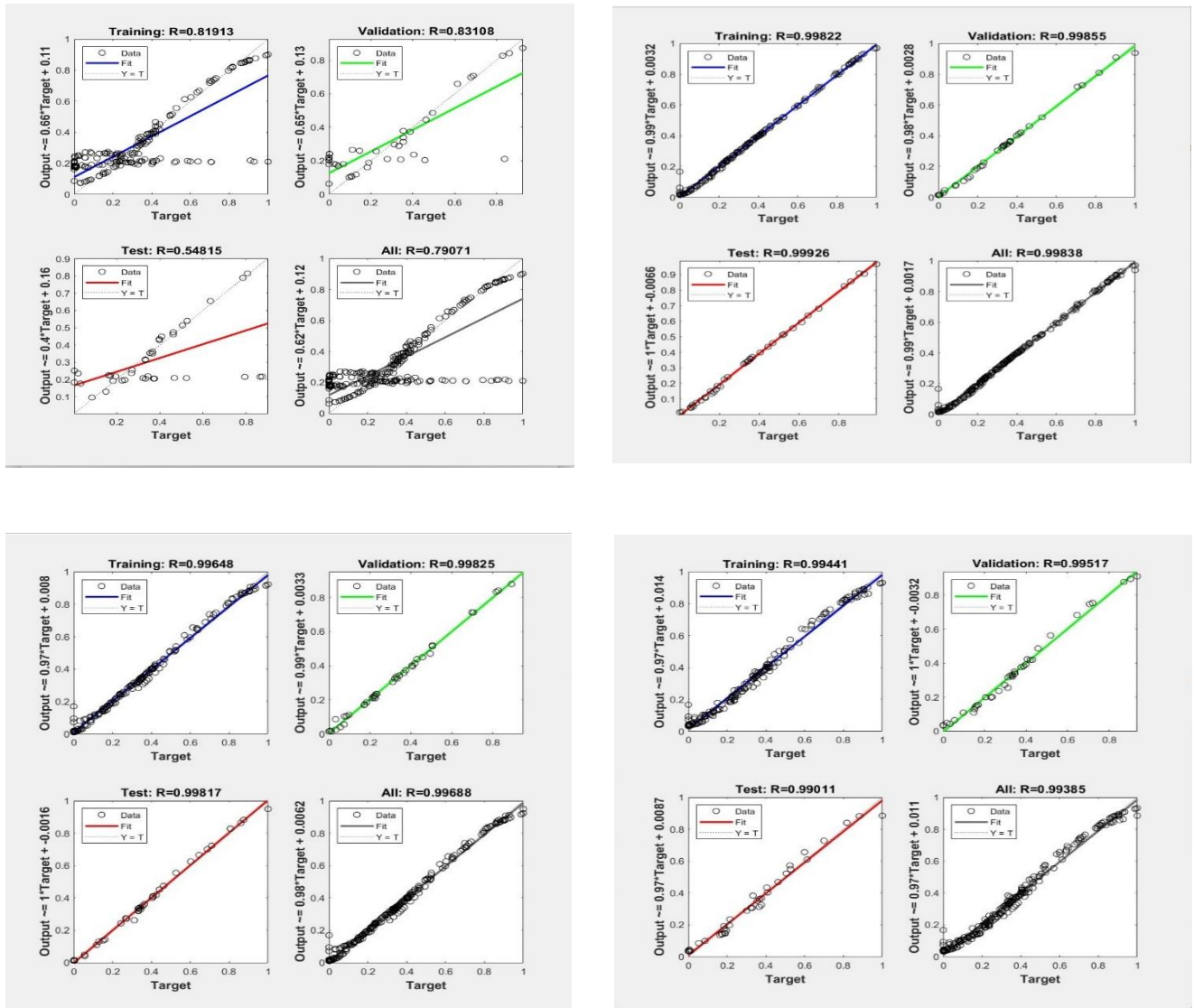
$$(X_{norm}) = \left(\frac{x - x_{min}}{x_{max} - x_{min}} \right)$$



B. Step 2. Feeding Data into Soft Computing

In the MATLAB language version 9.10.0.2198249 (R2021a), multiple program codes were developed, each with a different number of hidden layers and transfer functions. In other words, the number of hidden layers was calculated first, followed by an increase in the number of neurons from 1 to 4. As a result, the number of hidden layers was lowered, and 1 to 4 neurons were trained again to obtain different results. Finally, the best results were obtained by employing statistical factors. Data were divided into training (100 percent of total data), validation (100 percent of total data), and testing data sets at random (100 percent of the total data). Based on the testing methods, the best model was picked since a model can produce better results.

As a result, when the training procedure was completed, the findings were validated using 100% of the data that had not been included in the model building. Finally, the model was assessed using the remaining original data.



C. Step 3. ANN model performance assessment

Statistical parameters such as root mean square error (RMSE) [Equation 2], Nash-Sutcliffe Efficiency (NSE) [Equation 3], Scatter Index (SI) [Equation 4], and correlation coefficient (CC) [Equation 5] were used to evaluate the performance of the networks. The predicting error, which is the difference between the observed and predicted values using the equations below, is a common way to represent these parameters.

Equation 2: Root mean Square Error (RMSE)

$$RMSE = \sqrt{\frac{1}{N} \sum_{i=0}^N (P_i - O_i)^2}$$

Equation 3: Nash-Sutcliffe Efficiency (NSE)

$$NSE = 1 - \frac{\sum_{i=0}^n (P_i - O_i)^2}{\sum_{i=0}^n (O_i - \bar{P}_i)^2}$$

Equation 4: Scatter Index (SI)

$$SI = \frac{\sqrt{\frac{1}{N} \sum_{i=0}^n (P_i - O_i)^2}}{\bar{O}_1}$$

Equation 5: Correlation Coefficient (CC)

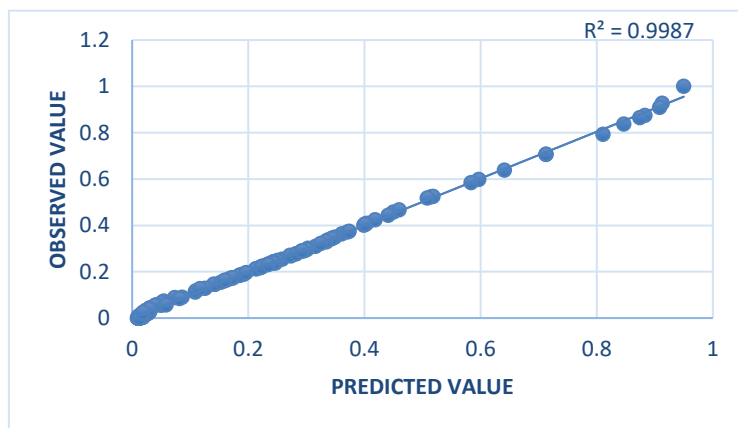
$$CC = \frac{\sum_{i=0}^n (P_i - \bar{P}_1)(O_i - \bar{O}_1)}{\sqrt{\sum_{i=0}^n (P_i - \bar{P}_1)^2} \sqrt{\sum_{i=0}^n (O_i - \bar{O}_1)^2}}$$

V. RESULTS AND DISCUSSIONS

Evaluation and error analysis of ANN models

To anticipate a link between geospatial data and yield, many ANN models were created. For nonlinear mapping between input and output parameters, a single-layer Backpropagation training network was used. Several designs were used in the training of all ANN models to produce the best outcomes for the network, including varied numbers of unique activation functions as well as different combinations of neurons in the hidden layer.

The first layer consisted of five input variables: temperature and precipitation with Production as the output variable. The optimal network has one input layer with two neurons, one hidden layers with one to four neurons, and one output layer with two output variable. The four metrics used to assess the network's performance: RMSE, NSE, SI, and CC. In the optimal network architecture, the hidden layers' activation function was chosen to be tangent sigmoid, whereas the output layer used a linear function.



Item	RMSE	NSE	SI	CC
ANN	0.00876	0.998	0.038	0.999

VI. CONCLUSION

Several ANNs were created, and the ANN model with 2 inputs, 70% training, 30% validation and testing, 4 Hidden Neurons, and 2 output structure generated the best results. The optimal ANN structure's root mean square error (RMSE), Nash-Sutcliffe Efficiency (NSE), Scatter Index (SI), and correlation coefficient (CC) were determined to be 0.00876, 0.998, 0.038, and 0.999, respectively.

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