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Research Article

Rainfall Forecasting of Vidarbha During the Monsoon Months of the Year 2022

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Abstract

In this work, the rain model for Vidarbha, an area which is prone to drought - is investigated based on four methods. These methods are: The Time Series method, The Fast Fourier Transform (FFT) method, the Artificial Neural Network (ANN) method, and The Root Mean Square (RMS) method.

Plots are made for rain amounts month-wise for June, July, August, September, and the total amount. This is followed by the frequency analysis of the total rain amount.

The predicted rain amount for this area is taken as the average result obtained by each of these methods.

Keywords: Monsoon Rain Prediction; Fast Fourier Transform Method; Water Shortage; Drought and Famine

Introduction and Literature Survey

Water scarcity affects large part of India [1-5]. There are many areas which have frequent drought condition and wells go dry, let alone having enough water to irrigate the fields [6-11]. The result is that the governments have to supply water by trains and trucks. For example, the city of Nagpur has to often arrange for water by allowing only half of its raw water to be used for domestic purposes. Five districts in Amravati division in Vidarbha - the drop of water level in reservoirs was very high. The average water stock in the reservoirs in five districts had in the past dropped to 19.7%. The drop in the water level triggered immediate supply of water using number of water tankers. Some of the districts in Marathwada quite often had faced shortage of drinking water.

In India, out of the surface water, 87% is stored in lakes, 11% in swamps and 2% in rivers. As all the sweet water is not extractable, only 1% of the total water can be used by humans [12]. Other references applicable for this region are available in public domain [13-26]. Water shortage also affects the hydropower generation [27].

Considering above mentioned facts, the present work makes attempt to arrive at a mathematics model to predict rainfall amount about 7 months in advance of the monsoon season. This is done to help farmers in planning for the next year's crop planting or to hydropower generators to plan ahead of time about this amount of rainfall in their reservoirs. The same applies to city planners or other industries where water is used in large amounts. The Indian Meteorological Department (IMD) also makes predictions but those predictions are in the months of April or May where the monsoon month starts in June. So, this prediction is of limited use because it comes when the farmers do not have sufficient lead time.

The farmers are usually under heavy loans and a drought has catastrophic effect on their financial planning or loan avoidance.

In addition, one can plan better for floods if there is a heavy rainfall in a given season. Other works which are useful in this respect can be seen [28-33]. The rainfall predictions by IMD can be seen in [34]. References [35], and [36] show the details about the Time Series method and FFT method. One can see the details of the ANN method in [37].

Methodology

In this work, the rainfall amounts are determined based on four methods which are: (1) the Time Series method, (2) the Fast Fourier Transform method (FFT), (3) the Artificial Neural Network method (ANN), and Root Mean Square method (RMS). The details about these methods can be known by going through references [35-38].

In the Time Series method, each of the months (June, July, August, and September) are considered as separate seasons. Again, one looks at the time history of 32 years just like in the previous method. However, here the minimization is taken by combining each of the four seasons (June, July, August, and September).

In the FFT method, one computes the Fourier coefficients using fast algorithm. Once, the coefficients are known then one can synthesize the Fourier series and evaluate the rain amounts at various instants of time.

In the ANN method one has to train the network using a batch of 32-year history - one at a time going back to the year 1874. Here, for every 32 years of data used as an input and the 33rd year data is used as the output. In this way, one progresses to the current year. Having trained the network this way, then, similar process is used for the prediction of the rainfall data expected in the year 2022.

In other words, one uses the relation between input and output using a linear system of equation

$$\{O\} = [W]\{I\} \text{---------- (1)}$$

where {O} and {I} are output and input vectors of sizes mx1 and nx1 respectively. The size of the weight matrix [W] is mxn.

While training, various sets of input vectors and output vectors are used and the search is for the elements of the [W] matrix which minimize the errors in Eq. (1). After the minimization, the output vector is determined for the new input vector using the optimized matrix [W].

The problem was solved using MATLAB Scientific Programs where feed-forward backpropagation method was used.

The particular parameters used were

Number of Nodes = 32.

Number of hidden layers = 1.

Number of epochs = 80,000.

In the RMS method one has to carry out the linear regression analysis based on minimizing the error of data points from the regression line using root mean square (RMS) values. This is done by taking the data over 32 years period. It is carried out for each of the months separately.

Results and Discussions

Figure 1 shows location of Vidarbha in India and also two mountain ranges - the Western and Eastern Ghats. The south-west monsoon approaches Vidarbha after the Western Ghats which are of higher elevations than the Eastern Ghats. These Ghats are obstacles to the rainfall for Vidarbha.

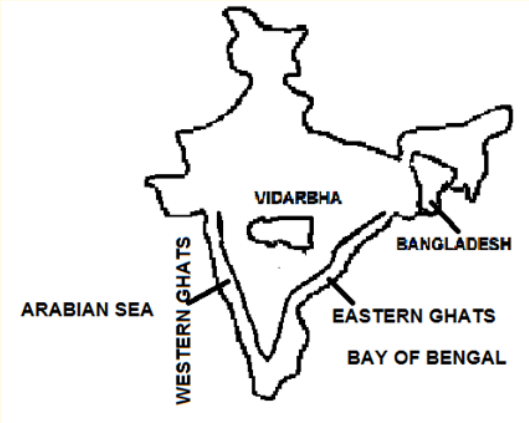

Figure 1: Location of Vidarbha between eastern and western ghats.

In figure 2, one can see the rainfall amounts for the month of June. This plot shows rain amounts for last 32 years. The results obtained using various methods have much less variations as compared to the actual rain amount. As written above, the methods used in the computations are: (1) Time Series method, (2) the Fast Fourier Transform method, (3) Artificial Neural Network (ANN) method, (4) Root Mean Square (RMS) method besides the actual rain values. The actual rain amount values change very drastically from year to year. On the other hand, table 1 shows that except for FFT method, other methods yield close results.

Method	Year	June	July	August	September	Total	Comments
Time series	**2022**	21.2	29.6	27.9	25.2	103.8	
FFT	**2022**	13.5	38.2	33.3	22.1	107.2	
ANN	**2022**	24.0	35.0	37.1	9.9	105.9	
RMS	**2022**	21.2	33.9	26.4	22.2	103.6	
Predicted amount	**2022**	20.0	34.2	31.2	19.9	105.1	More than the 32-year average value
32-year average		19.3	30.4	28.1	16.9	94.7	

Table 1: Rain forecast in centimeters for Vidarbha during 2022 monsoon months.

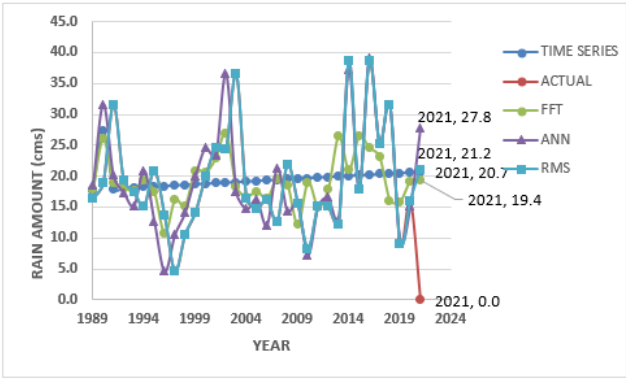

Figure 2: Rain amount in June 2021 in Vidarbha (cms).

Regarding the accuracy of each of the methods, one can look at the table 2. It shows that the average values obtained during the years 1990 to 2021 - the 32-year period. The results show that all the four methods yield accurate results.

Method	June	July	August	September	Total
Time series	19.4	26.6	25.1	22.5	93.7
FFT	16.9	30.4	28.1	16.9	94.7
ANN	18.5	30.7	27.9	18.3	95.3
RMS	19.3	30.4	28.0	16.9	94.7
Actual rain amount	19.3	30.4	28.1	16.9	94.7

Table 2: Average rain amount calculations in centimeters for Vidarbha during 1990-2021 period.

Figure 3 shows the results for the month of July. It also shows the actual rainfall values change very drastically. The amount of rain in July is more than that of June but there is slight increase in the values obtained by different methods. This is also shown in the table 1.

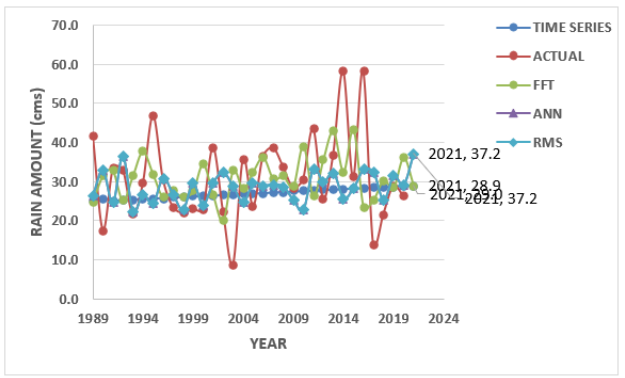

Figure 3: Rain amount in July 2021 (cms).

The values for August as shown in figure 4 are less than those of July. The table 1 also shows this fact. Figure 5 contains values for September which are less than that of August.

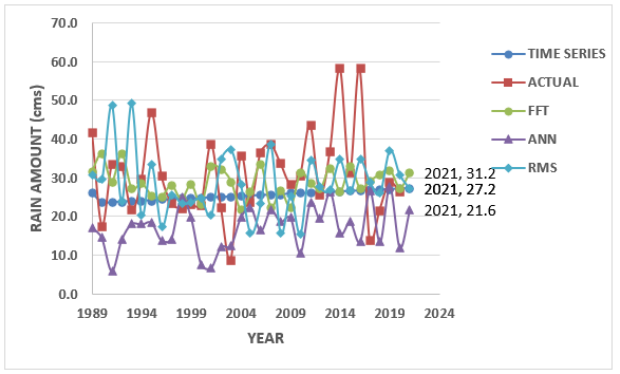

Figure 4: Rain amount in August 2021 (cms).

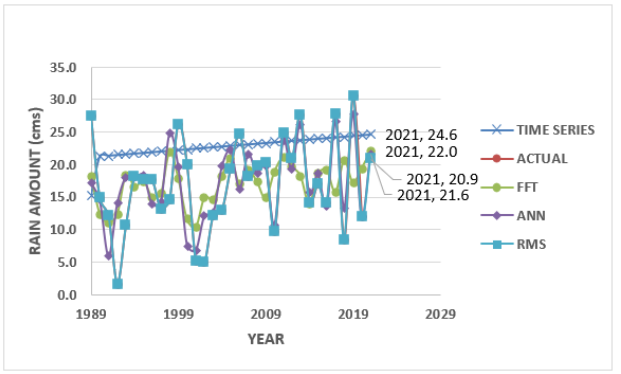

Figure 5: Rain amount in September (cms).

The rainfall amounts for September are shown in figure 5. Here the trend is much higher than the previous months which means the slope of the lines are steeper than those of the previous months. One can also see that the difference of the rain amounts given by various methods have much higher divergence. The average rain amount is September is much less than the previous two months but almost equal to that of June. It shows that there will be less rain in September as compared to July or August but it will be more than that of June.

Figure 6 shows the total rain values for the months of June to September. Here, the values obtained by various methods are much closer to each other than the results of the individual months. One can see in the table 1, the total predicted amount which is the average of the four methods, is significantly higher than the 32 year average values.

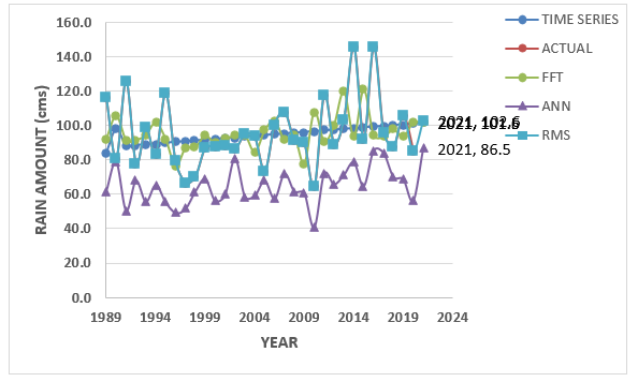

Figure 6: Total rain amount (cms).

Figure 7 shows the frequency distribution of the total rainfall values. The static component is not shown here. However, there are higher amplitudes present in the frequency numbers 1, 3,8,12, 13, and 14. And all higher than number 12. This explains the rapid changes in the actual rain values and that there are many sources that lead to higher rain amounts.

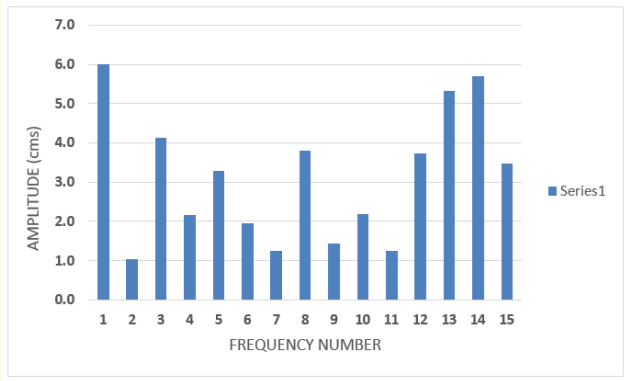

Figure 7: Amplitude versus frequency number.

Conclusions

- Looking at the table 1 one can say that this year, the rainfall will be significantly more than the average of the last 32 years.
- There are number of significant frequencies which have cause higher rain to amount this year.
- Higher amount rain values will lead to more water in the reservoirs.
- Even though the month-wise rain amounts vary quite a bit in various methods, but the scatter in the total rain values is much less.

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