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Analysis of Rain Model for Drought Prone Areas of India for the Year 2023

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Abstract

This data is analysed using four different methods which are: The Time Series method, The Root Mean Square (RMS) method, The Fast Fourier Transform (FFT) method, and the Artificial Neural Network (ANN) method. The Time Series method, The Root Mean Square (RMS) method, The Fast Fourier Transform (FFT) method, and the Artificial Neural Network (ANN) method. The predicted value using each of the methods is the average of these methods.

This predicted value is compared with the actual value. The reason why it is compared with the average value is because rainfall distribution has been found to be having a normal distribution where the mean or the average value has the maximum probability [1].

Introduction and Literature Survey

Where India has large agriculture area half of its population almost - is dependent on agriculture. In India, almost 66% of the agricultural land does not have irrigation facility [2-5]. Therefore, the lack of irrigation makes the land dependent on the vagaries of the rain. This uncertainty of rain exposes farmers to too high a risk. The risk involves the cost of seeds and fertilizers including payment for tractors for tilling the land. They borrow money at high interest rates. The failure of rain causes farmers suicides. Quite often there is drought to make matters worse. Furthermore, the rate of interest is quite high if they borrow money from the bank. This is even worse if they borrow money from the private lenders.

If the rains fail then the farmers do not have money to purchase daily needs thereby it decreases the overall prices of commodities of daily use.

If a reliable method of forecasting rain can be found then these tragedies of farmers suicide can be avoided. The news about farmers suicides can be read in the newspapers in the areas of Vidarbha, Marathawada, Telangana, and Jharkhand where the rainfall is highly unpredictable [6-32].

The lack of rain affects hydro-power generation also [33].

Another point to note is that the subsidies to the farmers in India is much less than those given to them in advanced countries [34].

This work has been undertaken to forecast rain around seven months in advance. Once the forecast is made and the information is available to the farmers then they can make appropriate decision as to how much they should be investing. This way the investment

will be based on reliable information and they will avoid getting into risky debt.

Figure 1 shows the areas of Maharashtra, Telangana, Jharkhand, and Vidarbha. In these areas the monsoon rain approaches from the southwest direction. There are two mountain ranges named the Western Ghat and the Eastern Ghat between the sea and these areas. Therefore, these four areas are in the shadows of both of these mountain ranges. Hence, the rain becomes not so dependable. Therefore, it is the existence of these mountain ranges which causes the uncertainty in the rainfall here. Not only the farmers but also other organizations such as the hydropower generators as well as various municipalities are also affected due to this uncertainty of the rainfall.

Figure 1: Location of Jharkhand, Telangana, Vidarbha, and Marathawada between the Eastern and Western Ghats of India.

In this work the calculations are 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 seen by going through the references [35-38].

The calculations in the RMS method involve linear regression based on root mean square (RMS) values. In these calculations one looks at the 32 year old history. This process is carried out for each of the months of June, July, August, and September.

In the Time Series method, the months of June, July, August, and September are considered as separate seasons. Even here, one considers the past 32 years of rain history.

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 1875. 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 which is 2022. Having trained the network this way, then similar process is used for the prediction of the rainfall data expected in the year 2023.

The problem of forecasting well ahead of time is necessited by the need of the farmers. The earlier the forecasting of the rain amount the better it will be for them to plan the next year's crop planting. The problem of earlier forecasting has not been addressed by any other researchers or even by IMD. The IMD forecasts are known to the people only in April and that too is revised again in July when the crops are already planted. This late revision does not help the farmers because they have already risked the capital when they planted the crops. This is the reason why the author has chosen to forecast seven months ahead of time.

The methods used in this work are time tested and widely used in the research field.

The Fast Fourier Transform (FFT) Method modelling of rain history is similar to what is done in signal analysis.

The Root Mean Square Method is based on minimization of errors of the entire rain history using linear regression analysis. This is commonly done in scientific works.

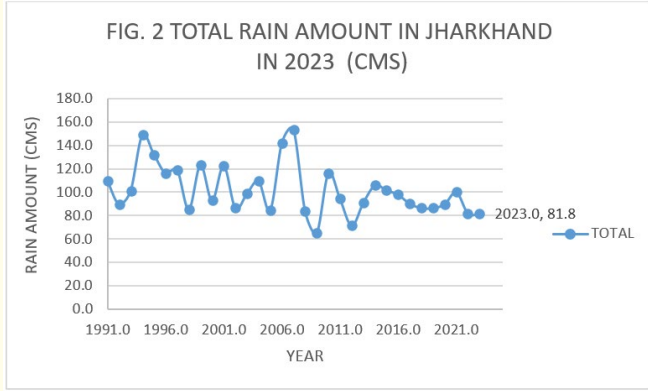
The Time Series Method divides the variations in each of the months into separate seasons and then overall trend is found using regression analysis. The basis is extended for the coming year's rainfall.

In the ANN Method which is an Artificial Intelligence Method, a linear model in form of weights - of the rain history going back to 1875 is arrived at. Then the reproducibility of the results of the past history is checked followed by the forecast for the coming year.

Finally, the average value of the results given by four methods is used for the actual forecast. The taking of the average is justified since the variation of the rainfall is very sharp from year to year which is not assumed in the models used for any of the methods.

Results and Discussions

Figures 2 to 5 show the total values of the rain for these areas which are- Jharkhand, Vidarbha, Telangana, and Marathawada. These figures show the fact that the rain amounts differ very sharply from year to another. It should be noted that the rainfall for Marathawada is the minimum considering last 32 years. This amount is vastly different or least among all other rain data which covers previous 32 years.



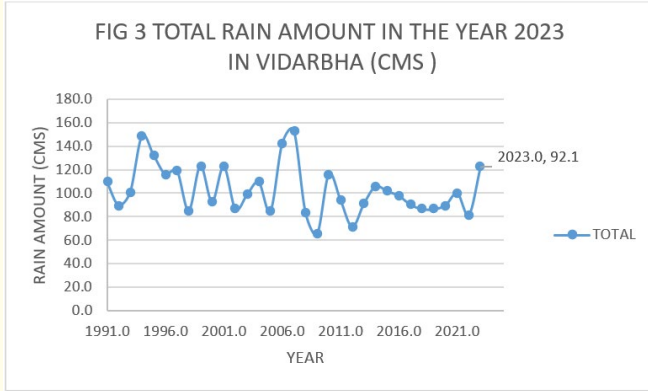


FIG 3 TOTAL RAIN AMOUNT IN THE YEAR 2023 IN VIDARBHA (CMS)
RAIN AMOUNT (CMS)
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
1991.0 1996.0 2001.0 2006.0 2011.0 2016.0 2021.0
YEAR
2023.0, 92.1
TOTAL

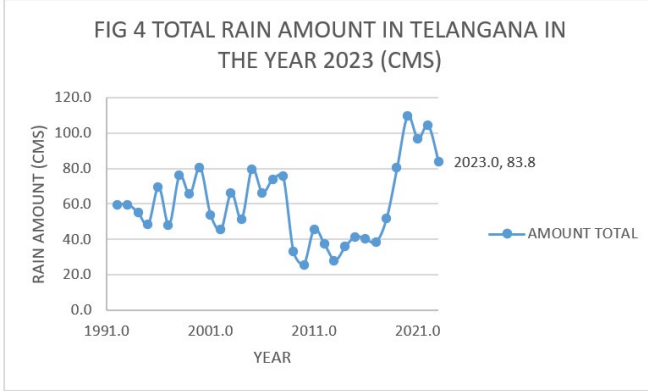


FIG 4 TOTAL RAIN AMOUNT IN TELANGANA IN THE YEAR 2023 (CMS)
RAIN AMOUNT (CMS)
120.0
100.0
80.0
60.0
40.0
20.0
0.0
1991.0 2001.0 2011.0 2021.0
YEAR
2023.0, 83.8
AMOUNT TOTAL

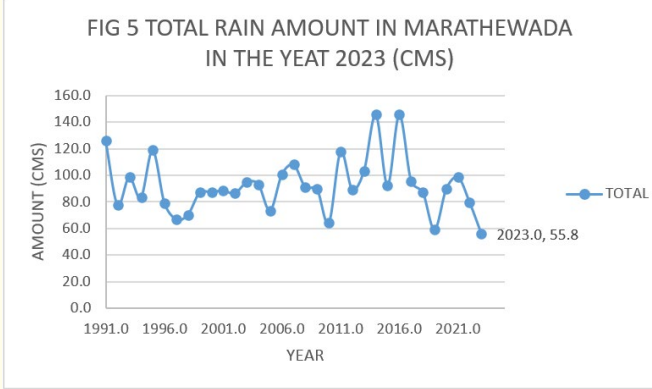


FIG 5 TOTAL RAIN AMOUNT IN MARATHEWADA IN THE YEAT 2023 (CMS)
AMOUNT (CMS)
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
1991.0 1996.0 2001.0 2006.0 2011.0 2016.0 2021.0
YEAR
2023.0, 55.8
TOTAL

Table 1 shows the results of various methods and the predicted amount based on the average value of all these methods. If we see the last column of this table which shows the errors obtained by various methods. It shows that these four methods have different errors and the predicted value is the minimum. Now, the results of the average of the past 32 years is much higher than that of the predicted value. Since, the rainfall follows a normal distribution hence the mean represents the most probable value and therefore, the predicted value based on this model- is better than the most probable value.

Method	*Year*	*June*	*July*	*August*	*September*	*Total*	*Percent of Absoute Error from Actual*
Time Series	2023	24.9	24.9	25.0	25.0	99.8	22.0
FFT	2023	16.1	31.7	27.5	22.9	98.2	20.0
ANN	2023	19.2	19.6	10.7	20.7	70.3	14.1
RMS	2023	12.1	30.5	26.7	18.4	87.7	7.2
Predicted Value=	2023	15.8	27.3	21.6	20.7	85.4	4.4
32 Year Average	2023	19.0	31.6	30.0	21.8	102.5	25.3
Actual Value	2023	9.57	25.7	58.6	81.8	81.8	0.0

Table 1: Rain Forecast in Centimeters for Jharkhand during 2023 Monsoon Months.

Table 2 shows the results for Vidarbha. Here, the predicted value shows higher error than the average value of the last 32 years.

Method	*Year*	*June*	*July*	*August*	*September*	*Total*	*Percentage Error from Actual*
RMS	2023	21.2	33.9	26.4	22.2	103.6	12.5
Time Series	2023	21.2	29.6	27.9	25.2	103.8	12.7
FFT	2023	13.5	38.2	33.3	22.1	107.2	16.4
ANN	2023	24	35	37.1	9.9	105.9	15.0
Predicted	2023	20.0	34.2	31.2	19.9	105.1	14.1
32 Year Average		19.3	30.4	28.1	16.9	94.7	2.8
Actual	2023	8.8	44.4	14.5	24.4	92.1	0.0

Table 2: Rain Forecast in Centimeters for Vidarbha during 2023 Monsoon Months.

Table 3 shows the results for Telangana. In this table the results of various methods show errors which are different but the predicted value is much less than those given by other methods. Here also, the predicted value is less than the 32 year average value.

Method	*Year*	*June*	*July*	*August*	*September*	*Total*	*% Absulutr Error from Actual*
RMS Method	2023	8.7	20.6	17.4	17.1	63.8	23.9
Time Series Method	2023	29.7	27.9	28.5	16.7	102.8	22.7
Fast Fourier Transform (FFT) Method	2023	11.5	17.0	19.0	15.3	62.8	25.1
ANN Method	2023	18.7	23.5	18.5	30.4	91.2	8.8
Predicted Amount	2023	17.15	22.25	20.85	19.875	80.15	4.4
32 Year Average		14.0	18.0	15.9	36.6	59.8	28.6
Actual Rain	2023	6.4	48.3	8	21.1	83.8	0.0

Table 3: Rain Forecast in Centimeters for Telangana during 2021 Monsoon Months.

Table 4 shows the results for Marathawada. As we have seen, the total rain this year was much less then any of the past 32 years. Hence, it is quite obvious that the errors would be far more consequently. The last column in this table shows this fact. Not surprisingly, the 32 year average also shows large errors. In this case the predicted error is less than the 32 year average value.

Method	*Year*	*June*	*July*	*August*	*September*	*Total*	*Percent Error*
ANN	2023	21.1	31.1	23.8	24.5	100.5	80.1
RMS	2023	18.1	30.7	28.6	19.8	97.6	74.9
Time Series	2023	18.0	28.7	26.3	15.7	88.6	58.8
Fast Fourier Transform	2023	18.8	32.1	25.6	6.2	82.6	48.0
Predicted Average	2023	17.4	31.2	26.2	14.4	89.1	59.7
32 Year Average		19.4	29.7	27.4	17.0	93.5	67.6
Actual	2023	4.1	29.1	4.7	17.9	55.8	0.0

Table 4: Rain Forecast in Centimeters for Marathawada during 2023 Monsoon Months.

Table 5 shows the errors obtained by the predicted value and the 32 year average value. This table shows that the results obtained by the predicted values for each of the areas - overall are less than the mean value of the last 32 years. This shows that the model proposed in this research is better than the most probable value.

Area	*Jharkhand*	*Vidarbha*	*Telangana*	*Marathawada*	*Average Percentage Error*
Predicted Percent Error by Author	4.4	14.1	4.4	59.7	20.7
32 Year Average	25.3	2.8	28.6	67.6	31.1

Table 5: Average Error in Calculations for All Areas.

Table 6 shows the performance of various methods. This table shows that the FFT method yields the best result and the ANN method - the worst among all these four methods.

Area	*RMS*	*Time Series*	*FFT*	*ANN*
Jharkhand	7.2	22.0	20.0	14.1
Vidarbha	12.5	12.7	16.4	15
Telangana	23.9	22.7	25.1	25.1
Marathawada	74.9	58.8	48.0	80.1
Average Percentage Error	29.6	29.1	27.4	33.6

Table 6: Percentage Error in Various Methods.

Conclusions

In the present work, the rainfall data of different drought prone areas of India were taken up. These data were analyzed using four different methods and the predicted value was based on the average results obtained by these four methods.

Figures 2 to 5 show the plots of rainfall data going back 32 years for four different areas mentioned above. In all these cases the rainfall sharply varies from year to year. The rainfall does not have any particular pattern.

Tables 1 to 4 dealt with the rainfall amount for specific areas. In these tables, the results of the proposed model yields better result than the 32 year average value except in one case which is shown in the Table 2. Overall, this model yields better result.

Table 5 shows that the predicted value for each of these areas except that shown in Table 2- yields better results.

Table 6 shoes that the FFT method performs the best and the ANN method - the worst among all the four methods.

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Volume 6 Issue 1 January 2024