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Literature Review

Modelling for Forecasting of Monsoon Rains in Areas Affected by Farmers Suicides

Anand M Sharan*

Professor, Mechanical Engineering Department, Faculty of Engineering, Memorial University of Newfoundland, ST. John's, Newfoundland, Canada

***Corresponding Author:** Anand M Sharan, Professor, Mechanical Engineering Department, Faculty of Engineering, Memorial University of Newfoundland, ST. John's, Newfoundland, Canada.

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Abstract

This research work is to come up with a rainfall model for monsoon rains in India. The goal is to forecast the rainfall amount about 7 months in advance. This advance forecasting is to help farmers in making decisions to plant crop based on the availability of water in the next season. This forecast is for helping hydro power generators and city water suppliers also.

The methods selected are based on the past 32 year rainfall history where four methods are used to determine the rainfall amount. These methods are: The Time Series method, the Root Mean Square method, The Fast Fourier Transform method, and the Artificial Neural Network method.

A forecasting model is considered valid if it falls within 19% of the actual rainfall amount. The number 19% is used by Indian Meteorological Department (IMD) to define a normal rainfall based on long term average.

Keywords: Monsoon Rain Prediction; Annual Rainfall; Rainfall Frequency Spectrum; Flood Control; Hydro-power Generation

Introduction and Literature Survey

India has vast areas and the south-west Monsoon rains arrive in the month of June and the four months starting with this month are considered as Monsoon rains. About 70% of India's crops are irrigated primarily by these rains. India's 80 to 90 water needs are derived from these rains. Poor Monsoon rains create havoc in the country where prices of most of things sold in the markets are affected by these rains. These rains affect the budgets of various governments. Not only this, the water supply of the entire country is drastically affected by these rains such as wells, dams, rivers go dry if the rainfall in this season is poor.

Not a year passes without farmers' suicides and it has continued year after year. The reason is that a farmer bears most of the liability of a crop failure as he borrows money from banks and money lenders at high interest rate. Many farmers do not even own their fields but they enter into contract and pay off the field owners before April of the year for planting crops. He has to buy fertilizers, and other supplies on cash basis by borrowed money. In case of crop failure he finds impossible to pay off debts and many commit suicide thereby making situation worse for his wife and children.

If a reliable model for rain prediction well in advance is developed then the farmers uncertainties can be avoided thereby many deaths can be avoided. The important areas where one reads about suicides are Vidarbha, Marathawada, Telangana, and Jharkhand where the rainfall is highly unpredictable. The picture of water scarcity and farmers suicides are given in [1-17].

The objective of this work is to predict the Monsoon rainfall about 7 months in advance thereby the farmer is well aware about the coming Monsoon rainfall quantities within a reasonable limits of error. In this case, the information is available well in advance of his purchasing of fertilizers, and other supplies and also it provides him with an opportunity to bargain with field owners about the rates he is willing to pay given the amount of expected rainfall.

Modelling of rain amount during the monsoon season

Monsoon rains prediction can be based on past 32 years of rainfall history. This data is collected by Indian Meteorological Department (IMD) year after year and they also make predictions around the month of April/May and then they revise their predictions. They predict the rainfall for various stations dispersed throughout the country.

Figure 1 shows various areas of interest of this paper. Since the Monsoon rains arrive on land from the south-west direction, they encounter the Western and Eastern Ghats (mountain ranges) of which the Western Ghats are higher than the latter. Those areas which fall in the shadow of these Ghats become rain deficient and prone to drought.

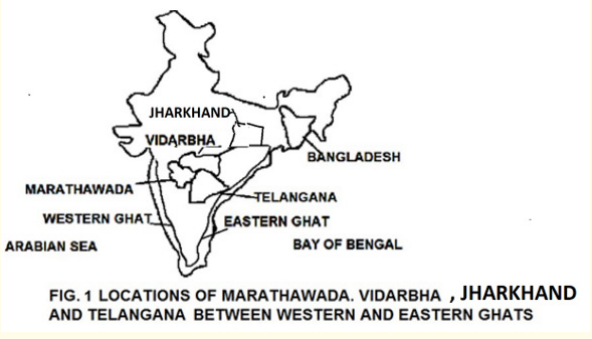

Figure 1: Locations of Marathawada. Vidarbha, Jharkhand and Telangana between western and eastern ghats.

The water shortage also affects hydro power generation and city water supply [18-20].

The calculations here 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). One can read about the theory behind these methods in [21-24]. In the RMS method, one calculates the root mean square value based on linear regression analysis for each of the months separately over time history of 32 years.

In the Time Series method, the amount of rainfall in each of the monsoon months – June, July, August, and September are considered as separate seasons in a given year. Then the overall trend is calculated for 32 year data using linear regression analysis. In calculations, the average departure of the rain for each of the months is also calculated.

In the Mean Square method, the linear regression is carried out monthwise and based on this –the corresponding rainfall amount is predicted.

In the Fast Fourier method, the history of the rainfall is approximated using Fourier series where the Fourier coefficients are calculated based Fast Fourier Transform algorithm. By following this algorfithm, the coefficients are arrived at with high computation efficiency. Based on the history and considering the trend – rain amount in the year 2020 is predicted.

In the ANN method to train the network, 32 year data from the year 1872 are used as the input vector and the rain amount in the 33rd year is used as the output vector. After this, next 32 year is obtained by incrementing the record of 1872 by the next record which will be year 1873. Consequently, the output vector becomes the 34th year from the year 1872. In this way, the final output vector will be the year 2019. After training the network this way, the prediction is made using the trained weights for the year 2020.

Results And Discussions

Figures 2 to 5 show the rainfall in each of the selected areas which are drought prone and where farmers suffer. The data consists of rainfall amount starting from the year 1988 to 2019. The values shown in these figures are the total values of each of the four months starting from June to September. The goal or the objective is to come up or predict the total amount of rainfall with an accuracy within a reasonable tolerance of the actual amount of rainfall.

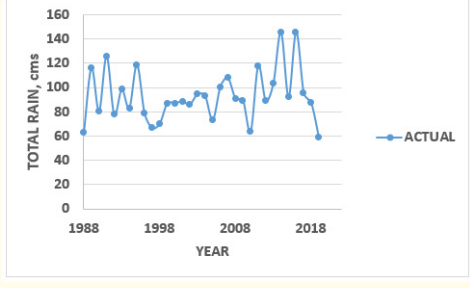

Figure 2: Total rainfall history of Telangana.

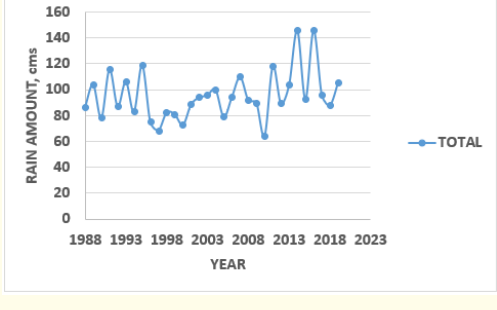

Figure 3: History of total rain in Vidargha.

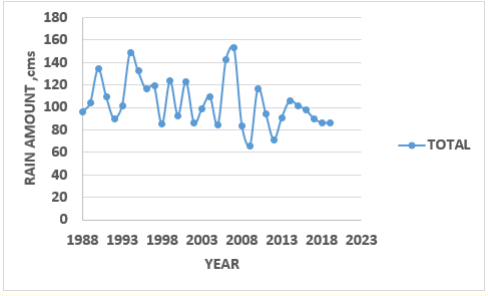

Figure 4: Total rain history of Jharkhand total.

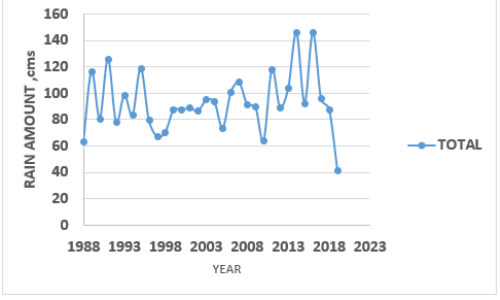

Figure 5: Total rainfall history in Marathawada

Tables 1 to 4 show month wise and the total amount of predicted rainfall for each of the areas selected and the actual total amount – the goal of this paper. Here, one can see month wise breakdown of the rainfall as calculated by each of the methods. The predicted amount in each of the table is the average of all the methods. In addition, the average over past 32 years is also given. The last column shows the percentage error from the actual rain.

The IMD considers 19% departure from the average rainfall as normal rainfall. Here, the validity of the model is also taken as within 19% of the actual rainfall. The last column shows the results obtained by this author and it also shows that of the IMD. The results in this table shows that the author's model as well as that of IMD are both valid but the author's model is more accurate.

Coming to the results for Vidarbha – they are shown in table 2. Even here, both models are valid where IMD's model is better.

In table 3, the results for Telagana, the author's model is very accurate whereas IMD's fails it is 31.3 percent far exceeding the limit of 19%.

In table 4 for Marathawada, the author's model is valid but that of the IMD fails as it exceeds 19% limit.

Method	Year	June	July	August	September	Total	Percentage error from actual
Rms	2020	19.5	34.7	27.3	20.8	102.3	13.8
Time series	2020	20.3	28.1	30.1	16.9	95.4	13.8
FFT	2020	20.4	28.5	26.8	24.2	99.9	6.1
ANN	2020	18.2	32.1	28.2	22.0	100.5	11.1
Predicted Average	2020	19.6	30.8	28.1	22.0	100.5	11.8
Actual rain	2020	20	25	30.3	14.6	89.9	0
Predicted by IMD	2020	19	33.2	29.8	23.4	105.4	17.2
32 year average	2020	19.1	30.5	28.5	17.1	95.2	17.2

Table 1: Rain forecast in centimeters for Jharkhand during 2020 monsoon months.

Method	Year	June	July	August	September	Total	Percentage error from actual
ANN	2020	18.2	32.1	28.2	22.0	100.0	17.5
Time series	2020	20.4	28.5	26.8	24.2	99.9	17.4
FFT	2020	20.3	28.1	30.1	16.9	95.3	12.0
RMS	2020	19.5	34.7	27.3	20.8	102.3	20.2
Predicted amount	2020	18.0	32.5	28.6	20.3	99.4	16.8
Predicted by IMD	2020	16.2	31.6	30.6	15.9	94.3	10.8
Actual rain	2020	16	26.3	30.8	12	85.2	0
32 year average		19.1	30.5	28.5	17.1	95.2	

Table 2: Rain forecast in centimeters for Vidarbha during 2020 monsoon months.

Method	Year	June	July	August	September	Total	Percentage error from actual
RMS values	2020	21.9	32.9	23	20.1	97.9	10.6
Time series	2020	29.6	28	28.5	16.7	102.8	6.1
Fast fourier transform (FFT)	2020	25.1	41.6	39.2	26.9	132.8	21.3
ANN method	2020	8.6	25.7	13.1	35.4	82.8	24.4
Predicted amount	2020	21.3	32.1	26.0	24.8	104.1	4.9
Predicted by IMD	2020	12.7	23.6	22.6	16.3	75.2	31.3
Actual rain	2020	16.4	25.8	42.3	25	109.5	0
32 year average		19.1	30.0	27.9	16.3	93.3	

Table 3: Rain forecast in centimeters for Telangana during 2020 monsoon months.

Method	Year	June	July	August	September	Total	Percentage error from actual
RMS linear	2020	19.5	34.7	27.3	20.8	102.3	18.1
FFT	2020	20.3	28.1	30.1	16.9	95.4	10.2
ANN	2020	11.7	32.1	28.2	22.0	94.0	8.5
Time series	2020	20.4	28.5	26.8	24.2	99.9	15.4
Predicted amount	2020	18.0	30.9	28.1	21.0	97.9	13.0
Predicted by IMD	2020	12.7	23.6	22.6	16.3	75.2	22.7
Actual rain	2020	16.4	25.8	42.3	25	86.6	0.0
32 year average		19.1	30.5	28.5	17.1	95.2	

Table 4: Rain forecast in centimeters for Marathawada during 2020 monsoon months.

The table 5 is a summary of all results and it again shows that the author's model is valid whereas that of the IMD fails by narrow margin. Hence, it fails when considered over much wider area.

These results show the lack of reliability of IMD results even though it does not give notice well in advance to the farmers or hydro power generators or to cities to plan in advance. It even revises its estimates well into May.

Area	Jharkhand	Vidarbha	Telangana	Marathawada	Average Percentage error
Predicted percent error by author	11.8	16.8	4.9	13.0	11.6
Predicted percent error by IMD	17.2	10.8	31.3	22.7	20.5

Table 5: Average error in calculations for all areas.

Conclusions

In the research work, four methods were used to arrive at results for forecasting. It was the average of the four methods as the criteria. Here, the data used was the 32 years history of the rainfall. The author's model has the capability for forecasting 7 months in advance of the commencement of the rainy season starting in the month of June of a monsoon season. The results were compared with those of the IMD whose forecasting is known only in April of the year with a possibility of a revision even in May thereby hardly giving any notice to farmers to avoid risks. First of all, it is the farmers who have maximum risk in case of drought or scanty rainfall. The banks, money lenders, seed suppliers, fertiliser suppliers are well protected as they sell on cash basis mostly.

The results show that IMD model fails in two out of four areas whereas the author's model is valid in all the four areas. Upon combining all results for all areas, the IMD results fail by slight margin whereas that of the author remains valid.

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