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Review Article

Rainfall Amount Forecast for the Year 2021 for Marathawada, India

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Abstract

This work discusses issues such as planting of crops based on availability of water. From literature survey it is determined that Marathawada has had severe water shortages,

In this work, the rainfall amount is predicted based on, four methods which are (a) the Fast Fourier Transform (FFT) method, (b) the Artificial Neural Network (ANN) method, (c) the Time Series method, and (d) the Root Mean Square (RMS) method. The predicted value is the average of four values obtained by these different methods. The average value this year will be slightly less than the average of last 32 years.

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

Water shortage in many Maharashtra regions

The location of Marathawada in Western India is shown in figure 1. Maharashtra is well known to be deficient in water and the sad part is that no solution to such acute problems have been found so far [1,2]. Certain crops like sugarcane require excessive water but such crops are planted here in large scale with the result that farmers planting other crops have to face water shortages.

Throughout India, encroachment of water bodies in the cities has caused water table to drop far below. The builders, seeing higher returns in constructing high- rise buildings are occupying land near water bodies and even filling up such bodies. This way there is vast shortage of water in the cities. References [3-5] provide sufficient information regarding such shortages.

About 40% of the cultivation land in India is irrigated by canals and by pumping the underground water whereas the remaining depend on the rain water. We know that between 75 to 90% of rainfall takes place during June to September period in India. With

Figure 1: Locations of Marathawada, Vidarbha and Telangana between Western and Eastern ghats.

the rise in population, the demand for water has been increasing. More and more pumps are being installed for dwellings which are now multi-storied buildings. Vast migration of workers from the rural areas to cities has resulted in excessive demand for water in the cities at the same time the water supply system of the cities are already overburdened.

To understand a farmer's risk in the event of crop failure, he borrows money for seeds and other supplies and pays in cash. However, the others involved in this chain are not participants in the loss process. The other sad part is that the food grain prices tumble when there is bumper crop. The food grain prices have an upper limit as far as return is concerned.

Water reserves exist in the form of (a) stored water in ponds, lakes, (b) those in flowing rivers plus (c) in form of snow or ice on the Himalayas as well as (d) as ground water. In case of deficient rainfall, the only option for most farmers is to get to the underground water whose level is getting deeper and deeper.

Water is needed in many sectors such as in agriculture, daily usage in cities and villages, power generation, as well as in many industrial processes. Other than the reserves mentioned earlier, it is the rainfall which meets the demand.

Marathawada has been drought prone in history and therefore, rainfall studies are very necessary.

As far as agriculture is concerned, water shortage results in large number of farmers suicides [6-10]. These shortage information can also be seen in [11-19]. Such a shortage also affects the hydro-power generation [20].

To help in facing such uncertainties of rainfall, it would be better if one can come up with a prediction model where one can compute the expected rainfall well ahead of time (crop planting and planning). This way, the farmers can decide what to plant and how much to plant? The farmers are under heavy loans and a drought destroys hope of paying back the loans. In case of advance knowledge about a drought or amount of rainfall- it will help farmers plan well ahead and avoid loans that they cannot repay.

In the present studies the prediction is based on 32- year rainfall history of an area. From studies done for separate areas - it has been found that in many cases a distance as little as 100 kilometers can lead to entirely different rain patterns.

These studies can also help in planning of hydro-electric power generation because the expected rainfall is predicted about 7 months in advance.

The results of this research can also be used in planning for dangers of flood. This is because dams have been built on rivers and their tributaries and if there is heavy rain over the catchment area then water from all the dams need to be released from time to time to avoid over-flooding of the dams. The simultaneous release of water from many dams causes flood in areas downstream.

There are other scientists who also publish their scientific works which can be seen in [21-28].

Analysis of historical data and predictions

In the calculations here, four methods were used 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 (RMS) method. In the RMS method, one calculates the mean of the square root value based on linear regression analysis for each of the months separately over time history of 32 years. Figure 2 shows a block diagram of the details of the computations.

In the Time Series method, the rainfall amount in each of the monsoon months - June, July, August, and September are considered as separate seasons in a given year [29]. 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 calculated. Here, the overall trend is used. To arrive at the predicted rainfall amount - the calculations use information for each of the four months of a year.

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

In the Fast Fourier method, the history of the rainfall is approximated using Fourier series using special algorithm to minimize the number of computations [30]. Based on the history and considering the trend - rain amount in the year 2021 is predicted.

In the ANN method, 32 year data from the year 1873 are used as the input vector and the rain amount in the 33rd year is used

Figure 2: Numbered block diagram of the computations.

as the output vector to train the network. After this, next 32 year is obtained by incrementing the record of 1873 by the next record which will be year 1874. Consequently, the output vector becomes the 34th year from the year 1873. In this way, the final output vector will be the year 2020. After training the network this way, the prediction is made using the trained weights for the year 2021. The details about this method can be seen in [31].

The result in summary form are presented in table 1.

Calculations of results are plotted month-wise for the months of June to September in figure 3 to 6 respectively. The total value plot is shown in figure 7.

Table 1 shows the summary of results. This table shows the results differ from each other in each of the months. Overall, there will be slightly lowerr rainfall this year as compared to the average rainfall of last 32 years.

In figure 3, the Time Series and Root Mean Square values have straight line variation due to the linear regression. The actual rainfall shows values which change abruptly from year to year. The RMS vales represent very closely all the points. The ANN values also show larger deviation on some instants. The Time Series values approach values obtained by other methods from the upper side. However, they approach each other towards the final year values.

Figure 4 shows the rainfall for the month of July. Here the trend is lower with years. In the Time Series values. The scatter in result is less than that of June. Again, actual rainfall change abruptly from year to year.

Method	Year	June	July	August	September	Total	Comments
FFT	2021	20.0	26.9	20.5	18.0	90.9	
Time Series	2021	26.2	24.6	25.1	14.7	90.6	
ANN	2021	22.9	18.0	17.3	28.2	86.4	
RMS	2021	21.9	31.3	25.1	18.1	96.3	Slightly less than the 32 Year Average Value
Predicted - Average of above	2021	22.8	25.2	22.0	19.7	91.1	
32 year average		19.3	30.3	27.8	16.6	94.1	

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

Figure 3: Rain amount in June (cms).

In figure 5 we see that the result is similar to figure 4 but the same decreasing trend is seen in RMS and Time Series methods values. The predicted rain is more than that of June.

The rainfall history for September is shown in figure 6. It shows the increasing trend. The amount of rainfall in this month is less

Figure 4: Rain amount in July (cms).

Figure 5: Rain amount in August (cms).

than those of months of July and August. Abruptness is there in the actual rain and in ANN values.

Figure 6: Rain amount in September (cms).

In figure 7, the actual rainfall values of different months were added up as total rain. The results were obtained as before. Here, there is overall not much difference in various method results - i.e. all yield closer final value for the year 2021. The FFT values also show sharp changes. The final values in figure 6 are shown in the table 1.

Figure 7: Total rain amount (cms).

Figure 8 is a plot of amplitudes versus frequency numbers based on the results of Fourier analysis. Here, we see that frequency numbers 1, 3, 13 and 14 have significant amplitudes. All of the amplitudes have been calculated using the Fourier series. The rapid variation of total rainfall from year to year is due to the presence of many significant higher frequencies.

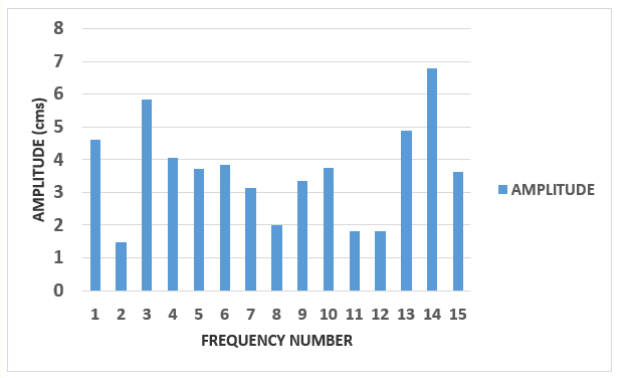

Figure 8: Variation of amplitudes with frequency number.

Conclusion

In this work a review of availability of water from different sources was discussed. It was mentioned that sugarcane crops require large amount t of water hence these are not suitable for places like Marathawada as various references show. The availability of water should be used for other crops which suffer due to the shortage of water.

It was seen that inadequate supply of water leads quite often to famer's suicides as it causes decrease in agricultural production. Lack of rain very badly affects the hydro-power generation. This shortage also affects living conditions in cities.

Based on this work one can conclude the following:

1. The historical rain data and the results of the present work show that this year there will be slight decrease in rainfall as compared to the average of last 32 years.
2. The presence of several significant frequencies in the rain spectrum - cause rapid change in the total rainfall.
3. The ever present water shortage suggests that better crop planting ought to be practised- the ones requiring less water ought to be considered for Marathawada.

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