Monsoon Rain Amount Forecasting for Jharkhand in the Year 2021

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***Abstract*— Life in India is sustained by monsoon rains because about 70% of agriculture here relies solely on these rains. In this work, the results of four methods are combined to arrive at the final result. These methods are: (1) Time Series method,(2) Fast Fourier Transform (FFT) method,(3) Artificial Neural Network (ANN) method and (4) Root Means Square (RMS) method. The final result indicates that this year - there will be about 8% less rain amount than the average of past 32 years.**

***Index Terms*— Monsoon rain prediction, annual rainfall, rainfall frequency spectrum, El Nino and La Nina influence on rainfall, drought and famine, crop failure.**

I. INTRODUCTION AND OBJECTIVE OF RESEARCH

Water shortages and drought are quite frequent in Jharkhand. Majority of farmers have small holdings and the region is hilly and rocky. Therefore, water does not stay in the fields which is needed in planting of rice crop. The rice is the staple food here. Due to rocky conditions – it is expensive to dig wells or build reservoirs here. The same is true about constructing canals which are quite common in Haryana or Punjab areas. The situation becomes grim if there is repeated monsoon failure.

Jharkhand is one among these places where the rainfall was short in the year 2019. In this year - Jharkhand suffered 35% shortage until July. Because this state is hilly, therefore distributing water from a reservoir becomes a difficult task. In addition, due to the land being rocky also -it makes the task of drilling wells or drawing water from the tube wells a challenging task.

Due to shortage of rain, people of Jharkhand have to purchase water to drink – let alone for planting crops [1-4]. It is no better in most parts of India as far as agricultural needs of water is concerned [5-14]. Lower output in agriculture affects the budget of the Indian government. Not only this, it also affects many industries of the country because of the decrease in rural consumption or the demand for corporate manufactured products. This causes problems in the budgets of governments at different levels.

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It goes without saying that this deficient monsoon rains lower down the levels of the water table, those of the reservoirs and rivers. The water shortage is being felt also in in 43 other countries where people are living below the 1,700 cubic meters per person threshold. Water stress has increased in regions such as China, India, and Sub-Saharan Africa, which has the largest population of the world.

Water shortage became so bad that in the state of California in United States of America (USA) - went through a six-year drought period. As a result of this, the hydroelectric power generation suffered. .

The effect of rainfall deficit on fields such as agriculture, city supply, and hydropower has been discussed in [15]. It is quite common to see the power generation decrease in summer months due to lower availability of water.

Monsoon rains in India have been also studied by many researchers such as in [16-24]. Moreover, the rainfall predictions by Indian Meteorological Department (IMD) can be seen in [25].

The map of Jharkhand is shown in Fig. 1. Jharkhand is a hilly area and water - after rains -flows out into rivers due to shortage of storage capacity in ponds and dams

The present study has been undertaken to improve the planning for water management and crop planting by farmers. The publication of results well in advance will help those who experience the scarcity of water.

II. RESULTS AND DISCUSSIONS

In Fig. 2 the Time Series results have small declining slope whereas the RMS results show fast decline in the rain amount with the passage of years. Both are straight lines due to the linear regression analysis. The actual, the FFT, and the ANN results show their variations about these straight lines. The actual rains undergo rapid changes. The theoretical details about these methods can be seem in [25-28]. The actual rainfall varies very rapidly and the variations are very wide. The predicted amount value is the average of results obtained by these four methods.

In Fig. 3, there is a positive slope in the two regression lines corresponding to the Time Series and RMS methods where the actual results vary over wide range. The ANN method and the FFT method results have lesser variations as compared to the actual rain plot.

In Fig. 4, all the results converge as the years increase to the right. The amplitudes of variation of the actual, FFT, and the ANN methods decrease with time.

In Fig. 5, there is an increasing trend in the regression straight lines but the variable amplitudes are large for the rest of the three other plots but they oscillate about the RMS results.

The total values of rain shown in Fig. 6 show a slight decreasing trend but the variable amplitudes show a decaying behavior resulting in decreased span of variations in the estimated rainfall in 2021. In this figure, the Time Series results are higher than the RMS method. The actual curve shows wide fluctuation in the beginning but it also shows damped out amplitudes as we approach this year's rain amount.

The Fig. 7 shows the amplitude versus frequency number plot. Here, frequency numbers 1, 6, 8, and 10 are significant frequencies having amplitudes greater than 5 cms, which are quite high.

Fig 8 shows details of computations in the form of a block diagram.

The Table 1 is a summary of all results which shows that this year we will have 8% less rainfall than the 32 year average. There is a very wide variation between the Time Series and FFT values on one side and the ANN values which are quite low. The RMS value does show near the mean. However, the RMS value predicts close to the mean as the name suggests.

III. Conclusion

This work involved the estimation of monsoon rainfall for the year 2021 using four methods- (1) ANN method, (2) the Time Series method, (3) the FFT method, and the (4) RMS method. The Time Series method, and the RMS methods involve linear regression technique hence their plot correspondingly is a straight line. . The FFT and the ANN methods results show fluctuations but not as much as those in the case of the actual rainfall.

Based on this study one can conclude the following:

1. The actual rainfall pattern has sharp and abrupt variations hence difficult to approximate by any numerical method.
2. The Time Series method, and the RMS method use linear regression where the errors are minimized.
3. The FFT method results are approximated by Fourier series whose coefficients are determined by a fast algorithm.
4. Overall, considering all the methods, the results obtained in Table 1 indicate that this year's rain will be slightly lower than the 32 year average.

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TABLE 1: RAIN FORECAST IN CENTIMETERS FOR JHARKHAND DURING 2021 MONSOON MONTHS

METHOD	YEAR	JUNE	JULY	AUGUST	SEPTEMBER	TOTAL	COMMENTS
RMS	2021	11.1	33.1	27.8	18.3	90.3	
TIME SERIES	2021	22.7	39.0	35.8	24.9	122.4	
FFT	2021	22.9	42.0	29.3	24.6	118.8	
ANN	2021	8.7	16.1	18.8	8.4	52.0	8.0 % LESS THAN 32 YEAR AVERAGE
PREDICTED AVERAGE	2021	16.4	32.6	27.9	19.1	95.9	
32 YEAR AVERAGE	2021	19.5	32.8	30.2	21.8	104.2	

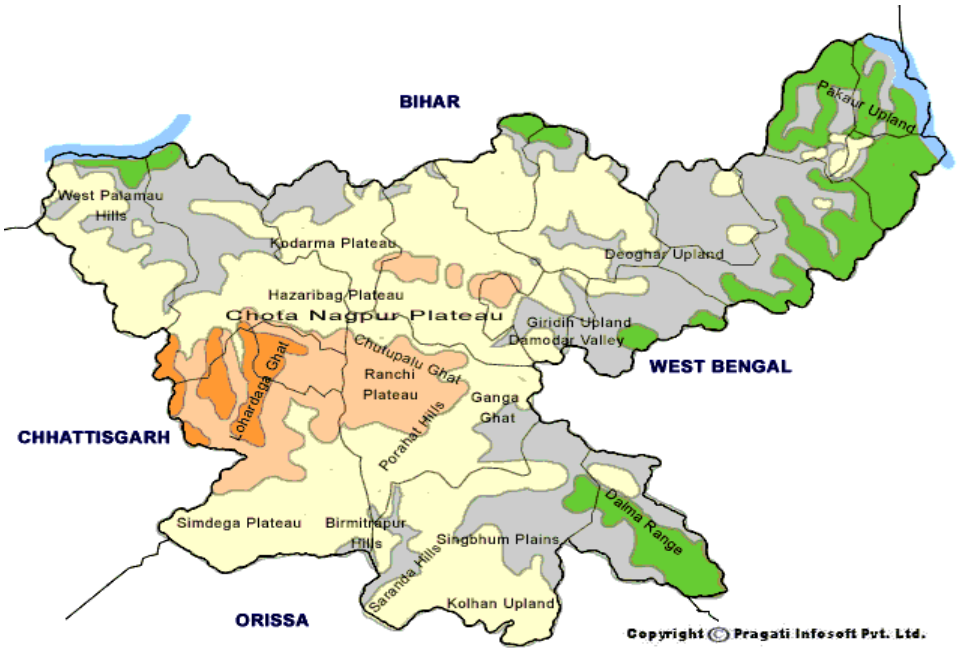


FIG 1 PHYSICAL MAP OF JHARKHAND, INDIA

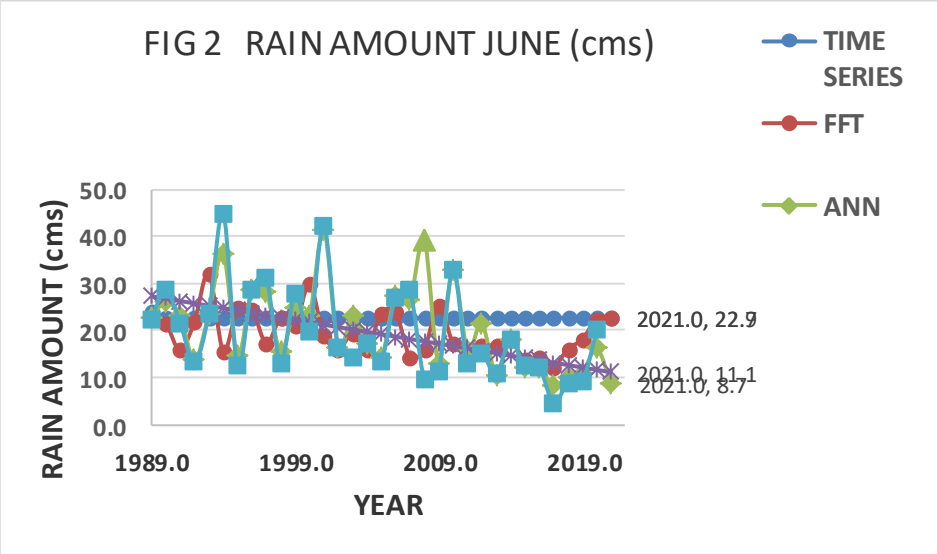


FIG 2 RAIN AMOUNT JUNE (cms)
TIME SERIES
FFT
ANN
RAIN AMOUNT (cms)
50.0
40.0
30.0
20.0
10.0
0.0
1989.0
1999.0
2009.0
2019.0
YEAR
2021.0, 22.9
2021.0, 11.1
2021.0, 8.7

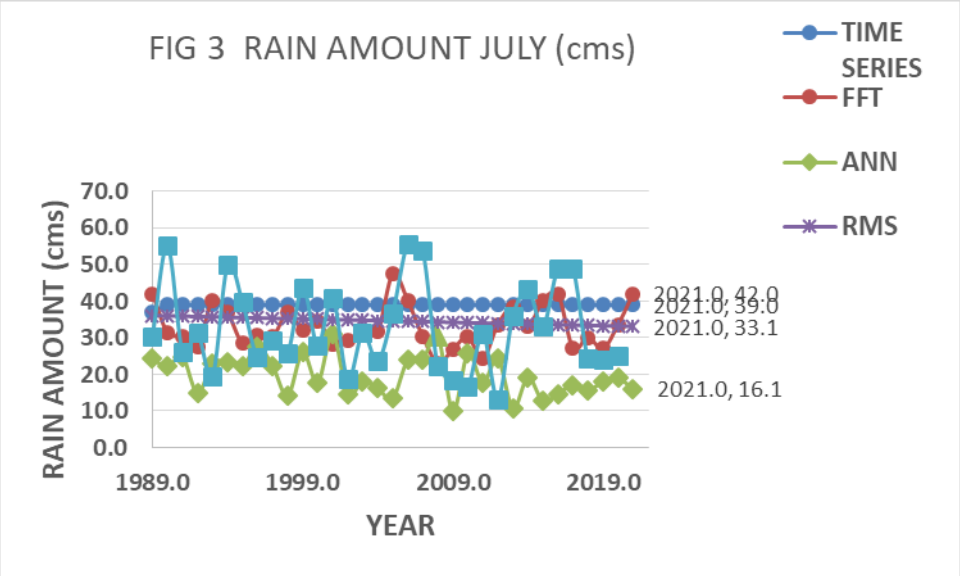


FIG 3 RAIN AMOUNT JULY (cms)
TIME SERIES
FFT
ANN
RMS
RAIN AMOUNT (cms)
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
1989.0
1999.0
2009.0
2019.0
YEAR
2021.0, 42.0
2021.0, 39.0
2021.0, 33.1
2021.0, 16.1

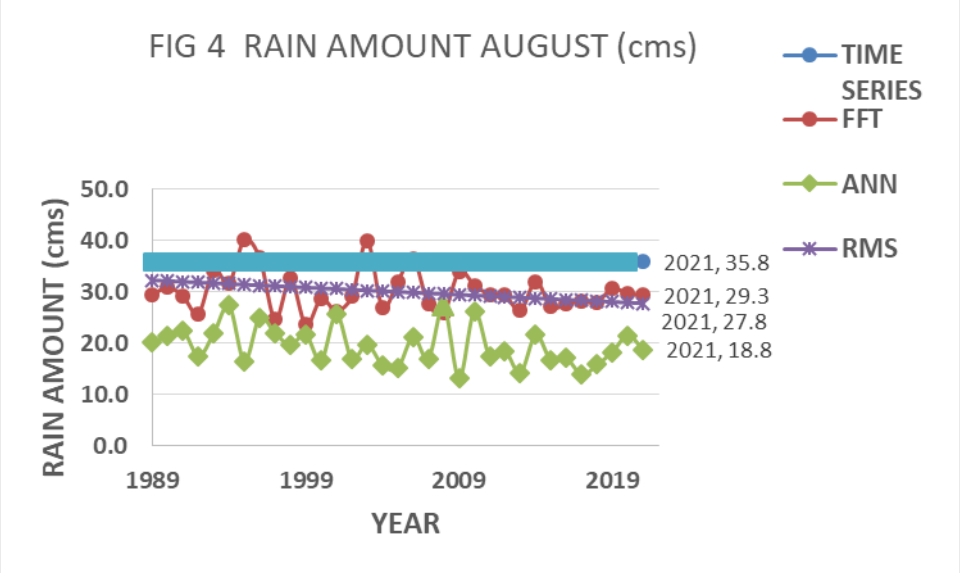


FIG 4 RAIN AMOUNT AUGUST (cms)
TIME SERIES
FFT
ANN
RMS
RAIN AMOUNT (cms)
50.0
40.0
30.0
20.0
10.0
0.0
1989
1999
2009
2019
YEAR
2021, 35.8
2021, 29.3
2021, 27.8
2021, 18.8

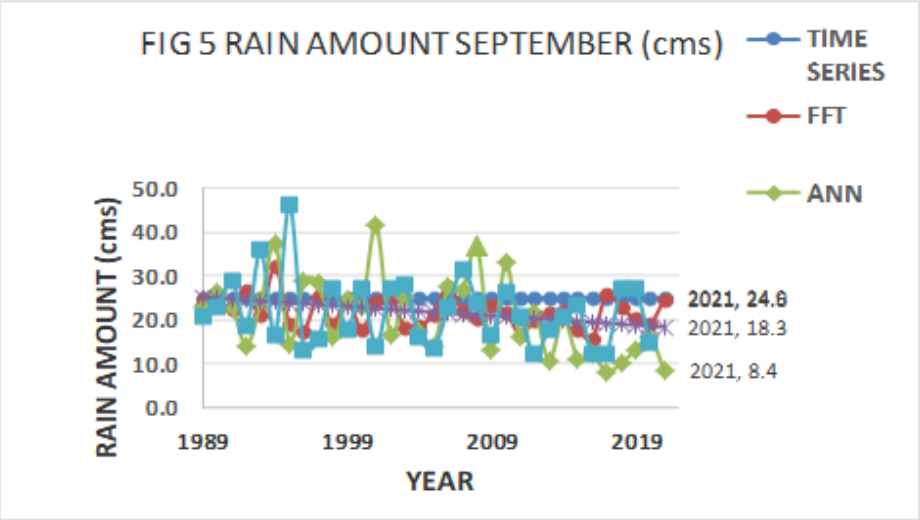


FIG 5 RAIN AMOUNT SEPTEMBER (cms)
TIME SERIES
FFT
ANN
RAIN AMOUNT (cms)
50.0
40.0
30.0
20.0
10.0
0.0
1989
1999
2009
2019
YEAR
2021, 24.8
2021, 18.3
2021, 8.4

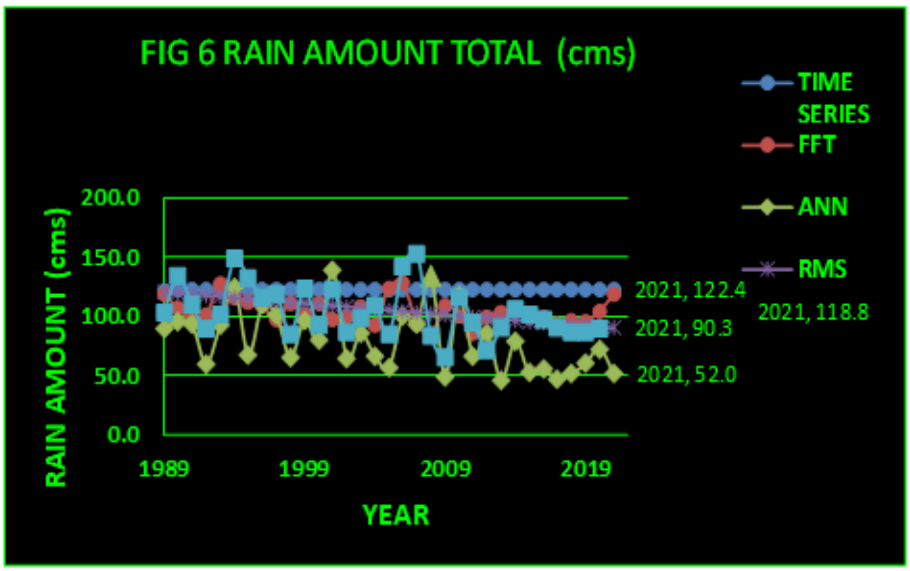


FIG 6 RAIN AMOUNT TOTAL (cms)
TIME SERIES
FFT
ANN
RMS
RAIN AMOUNT (cms)
200.0
150.0
100.0
50.0
0.0
1989
1999
2009
2019
YEAR
2021, 122.4
2021, 90.3
2021, 52.0
2021, 118.8

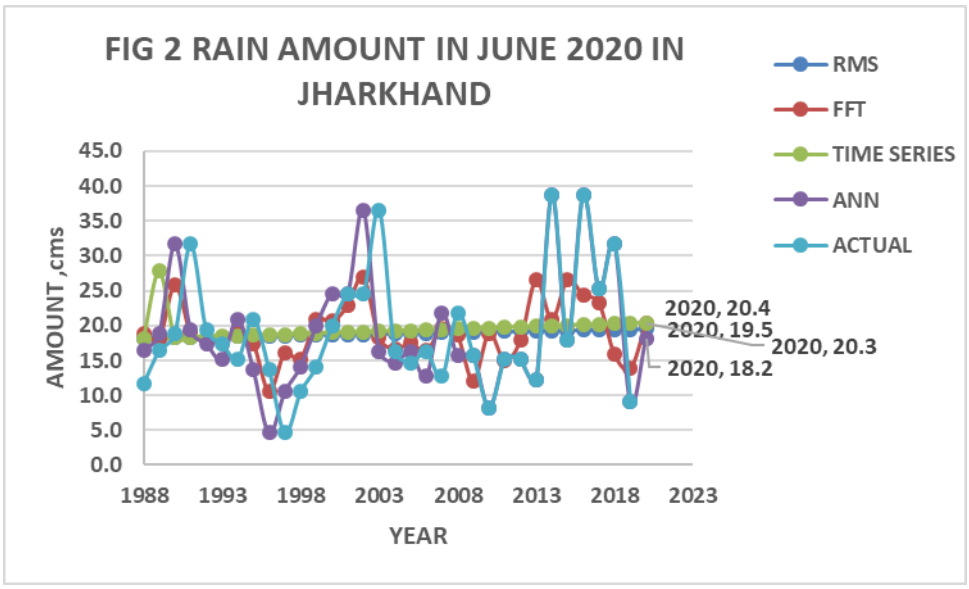


FIG 2 RAIN AMOUNT IN JUNE 2020 IN JHARKHAND
RMS
FFT
TIME SERIES
ANN
ACTUAL
AMOUNT ,cms
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
1988
1993
1998
2003
2008
2013
2018
2023
YEAR
2020, 20.4
2020, 19.5
2020, 20.3
2020, 18.2

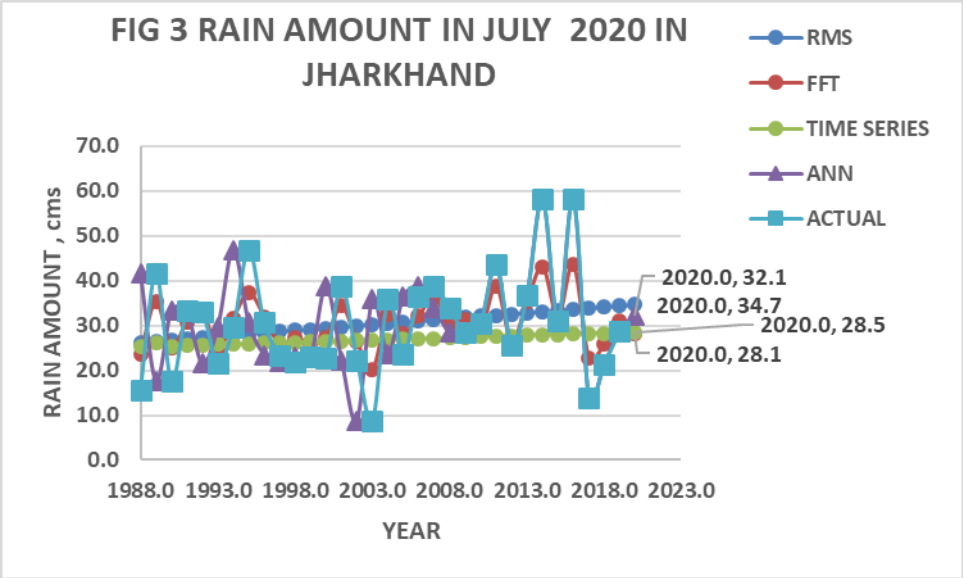


FIG 3 RAIN AMOUNT IN JULY 2020 IN JHARKHAND
RMS
FFT
TIME SERIES
ANN
ACTUAL
RAIN AMOUNT , cms
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
1988.0 1993.0 1998.0 2003.0 2008.0 2013.0 2018.0 2023.0
YEAR
2020.0, 32.1
2020.0, 34.7
2020.0, 28.5
2020.0, 28.1

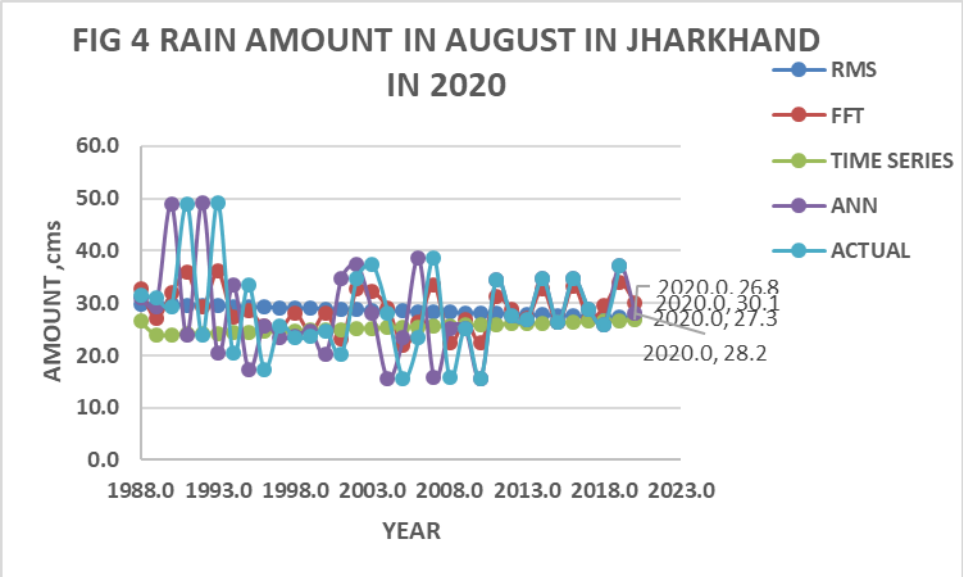


FIG 4 RAIN AMOUNT IN AUGUST IN JHARKHAND IN 2020
RMS
FFT
TIME SERIES
ANN
ACTUAL
AMOUNT ,cms
60.0
50.0
40.0
30.0
20.0
10.0
0.0
1988.0 1993.0 1998.0 2003.0 2008.0 2013.0 2018.0 2023.0
YEAR
2020.0, 26.8
2020.0, 30.1
2020.0, 27.3
2020.0, 28.2

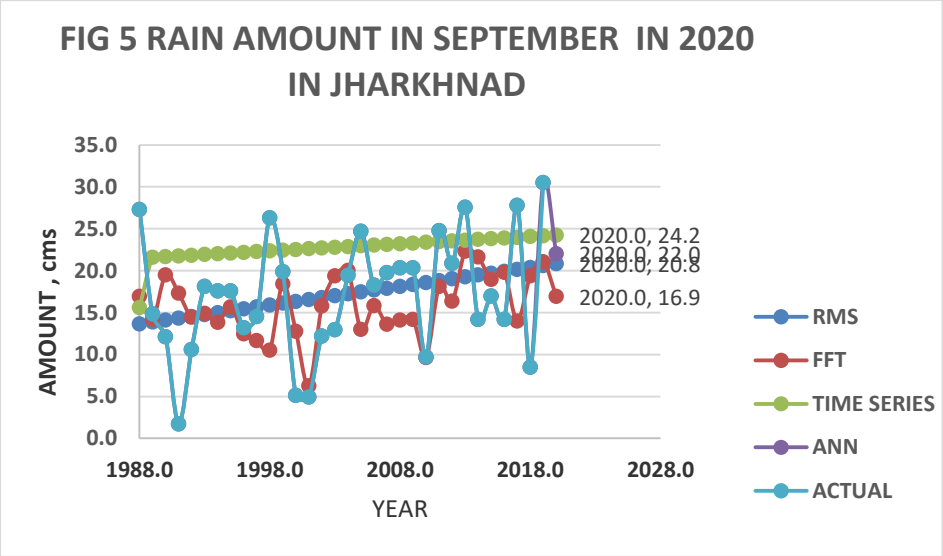


FIG 5 RAIN AMOUNT IN SEPTEMBER IN 2020 IN JHARKHNAD
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
AMOUNT , cms
1988.0
1998.0
2008.0
2018.0
2028.0
YEAR
2020.0, 24.2
2020.0, 22.0
2020.0, 20.8
2020.0, 16.9
RMS
FFT
TIME SERIES
ANN
ACTUAL

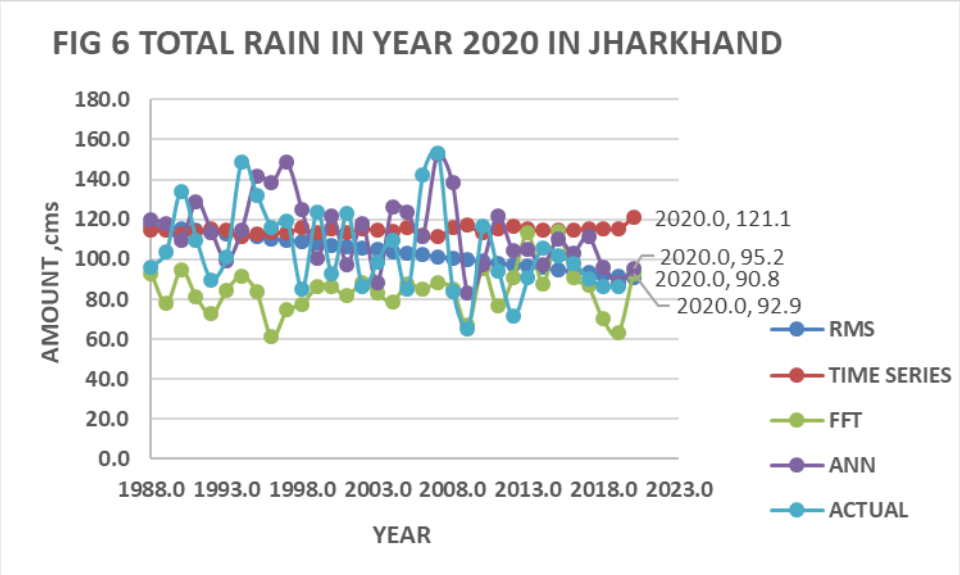
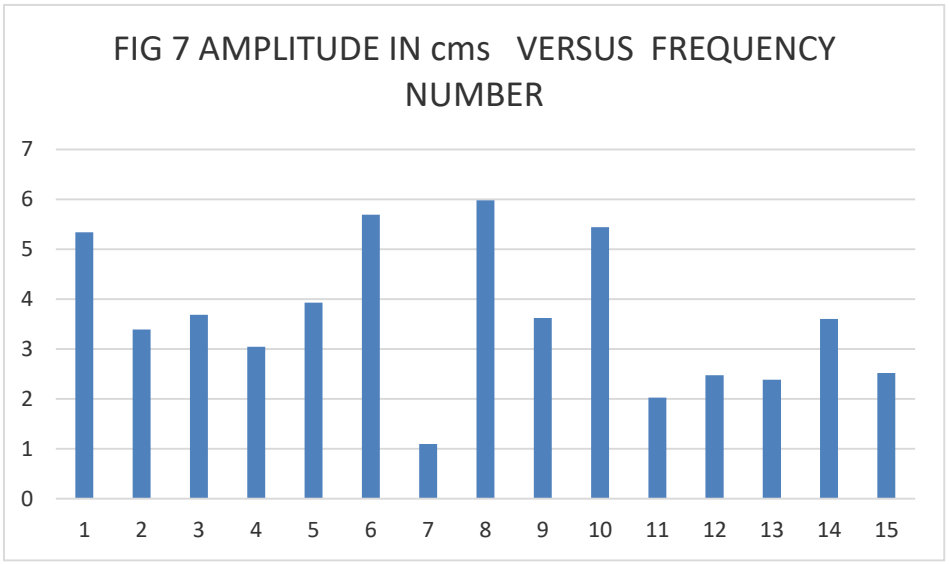


FIG 6 TOTAL RAIN IN YEAR 2020 IN JHARKHAND
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
AMOUNT ,cms
1988.0 1993.0 1998.0 2003.0 2008.0 2013.0 2018.0 2023.0
YEAR
2020.0, 121.1
2020.0, 95.2
2020.0, 90.8
2020.0, 92.9
RMS
TIME SERIES
FFT
ANN
ACTUAL



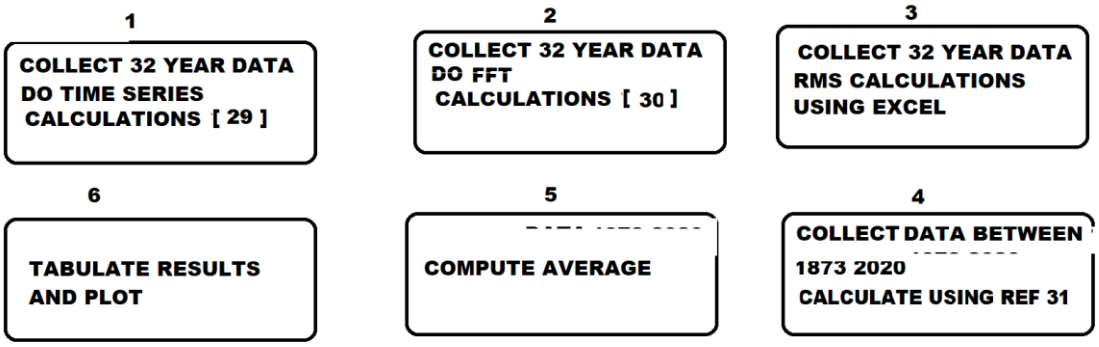


FIG. 8 NUMBERED BLOCK DIAGRAM OF THE COMPUTATIONS