PREDICTION OF RAIN IN VIDARBHA, INDIA BASED ON VIDARBHA'S HISTORICAL RAIN DATA

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ABSTRACT

In this work the prediction of rain is based on average of two methods. In these methods, historical rain data of Vidarbha between 1981 to 2012 are selected for projection. These methods take into account the trends in rain pattern also.

Among the results are the effects of El Nino and La Nina which have significant effect on annual rainfall. The period of these combined effect found is 10.67 years. The average rainfall of Vidarbha is 35.440 inches. The normal range of rain varies between minus 19% of the mean to plus 0.19 % of the men value.

The forecast is being made in November 2014 for the Year 2015 that the rain will be deficient in the month of June.

The advantage of this approach is that it gives farmers far more time than they get presently when preliminary predictions are announced by Indian Meteorological Department in April for each monsoon.

KEYWORDS : Monsoon rain prediction **,** annual rainfall**,** rainfall frequency spectrum, El Nino and La Nina influence on rainfall, drought and famine, crop failure

1. RAIN AND AGRICULTURE

India is primarily dependent on its agricultural output which constitutes its major fraction of GDP. The agriculture sector is highly dependent on rain which India gets from South –West monsoon rains (from the Arabian Sea) and from the Bay of Bengal. These rains occur during the months between June to September. Precipitation in form of rain, has a dramatic effect on agriculture.

Rising energy costs such as Diesel fuel used in pumps - have added to the country's foreign exchange needs and India is highly deficient in energy sources. This requires that the information about the amount of rain to be expected in coming season be known as accurately as possible.

Another factor which is playing havoc in the rainfall is the global warming which has introduced increased uncertainty in preparing for planting crops. This planting period is very sensitive and critical otherwise the farmers would have to wait for another year where these people do not have alternate means to earn their living. Such crop failures lead to large scale migrations from the villages to cities where people can earn some money to survive. This migration causes increased load on city's services and it increases slum areas in the cities.

Vidarbha lies in the Central India as shown in Fig. 1 where its location is away from both the Western Ghats and the Eastern Ghats from where the monsoon approaches the Indian subcontinent. It rains heavily between the Ghats and the sea but these Ghats act as a barrier for smooth rainfall transition between the coast and inland. Therefore, a steep gradient in rainfall exists between the coasts and Vidarbha. To the south of Vidarbha is the Telangana region and on the southwest is the Marathwada region, and even these regions suffer from droughts from time to time.

In history, Daulatabad near Aurangabad in Marathawada, starting in 1327, it famously remained the capital of Tughlaq dynasty, under Muhammad bin Tughluq (r. 1325-1351). He forcibly moved the entire population of Delhi here, for two years, before it was abandoned due to lack of water.

The news about farmers suicides is widespread ; the author was drawn to such a news and wanted to understand the problem closely [1-3]. Bihar is another region where droughts take place but not much news about suicides is published in the newspapers [4] .

2. RAIN PREDICTION IN INDIA

India's primary information about rain comes from India Meteorological Department (IMD) [5] . India has emphasized fair amount on research on rain predictions. It is known that monsoon is predicted either by statistical models based on analysis of historical data to determine the relationship of Indian Summer Monsoon Rainfall (ISMR) , to a variety of atmospheric and oceanic variables over different parts of the world prior to the summer monsoon season, or by dynamical models based on the laws of physics [6,7]

Irrespective of methods used above, their validity over large tract of land area cannot be held as reliable because of their dependence merely on atmospheric and ocean parameters. Bihar happens to be a far distant land where the monsoon clouds reach after spreading over large land area. The convective conditions over the land areas are entirely different.

In view of the above argument, there is a need to have an alternate and reliable method of prediction for places like Vidarbha because the agriculturists are mainly of lower income group and un-reliability of rainfall causes intense hardships.

Fig. 2 shows the rainfall progression with time in 2014 in Central India. It shows that the amount of rainfall is very low in the month of June but builds up later in months of July to September. The crops can fail if (a) there is scanty rain in June or (b) the total rain is not sufficient. In other words, timeliness of rain is very critical.

3. RAIN DATA AND ANALYSIS

Figs. 3 to 7 show plots of yearly rains starting from 1981 to 2012 for the, months of June to September whereas Fig. 7 shows rains for all these months in combined form. This shows a slightly but not much declining trend from year to year. This record (Fig. 7) has on an average or the mean value of 35.440 inches of rain. Indian Meteorological Department defines normal rain if the values lie between plus or minus 19% of the mean value. Although

in absolute sense, this mean varies from region to region. One can clearly see that the plot has many ups and downs. However, low amount of rain causes drought conditions such as in 2009 in Fig. 7.

The first important factor which ought to be emphasized is the timeliness of rain for planting crop [4]. If the rain is delayed too much even then the hardship is going to be there. Fig. 3 shows the variation in rain in the month of June starting from the year 1981. It shows that there exists history of deficient rain i.e. rain below lower limit. The lower or upper limits are 19% of the mean value. In these years, the farmers have difficulties in planting the crop.

The farmers need fair bit of advance information to plan for seeds, and other necessities like finance to negotiate from the banks or other lenders. As is, India has much higher interest rates on loans compared to advanced countries which also have higher subsidies from their respective governments. The uncertainties in rain cause hardships even suicides amongst the farmers [1-3]. They borrow money at high interest rate and crop failure puts them in awkward position where they could lose their houses or other assets by defaulting on payments.

Fig. 4 also shows that in the past many years the rainfalls were deficient in July. Fig. 5 also shows deficient rains in many years- more than July months. As far as the months of September (refer to Fig. 6) are concerned, the rains have been either above or near the upper limit or below or near the lower limit.

To get better insight into the total amount of rain over the years one can see Fig. 7. The same data was analyzed in the frequency domain using Fast Fourier Transforms (FFT), and the results are shown in Fig. 9 [8, 9]. It shows frequency numbers which are quite significant are 3, 8, 13, 14, and 16. It, the number 3, does point to the El Nino or its counterpart La Nina effect which occur every 10.67 years. Remarkable fact is that numbers 13, 14, and 16 having much higher frequencies have greater amplitudes. This shows that the change in rain amount will be very rapid from year to year. This rapid fluctuation in the amount of rain throws off the planning for the crops

This rainfall data's statistical distribution was plotted and the result is shown in Fig. 8 which shows a normal distribution. This was further checked using chi squared test using software called MATLAB.

All figures – 3 to 7 show plots of the actual data and the results of FFT method i.e. after obtaining Fourier coefficients using FFT; the time dependent results were calculated using the Fourier series. It shows a very close match between the two (actual and its FFT model).

4. RAINFALL PREDICTION

It was not possible for the author to obtain data beyond 2012. Year 2013 onwards, the rain data for Vidarbha were not posted on its (IMD's) web i.e. region by region data on IMD website.

India is a country which depends upon agriculture as one of its main component of the GDP. Therefore, the government ought to be current in providing information in the public domain for better productivity in the agriculture sector. The information should not be kept a secret but it should be widely available in the IMD's regional offices as well as state governments offices in full public view.

Similarly, IMD's monsoon predictions should be reliable - region by region. For example the farmers of Vidarbha should know the amount of rainfall that is going to be next year, first as early as possible for planning the crops and as accurately as possible. This is not the case presently unfortunately.

Table 1 shows the results for June for years 2013 onwards. Here the results of the Time Series method were arrived at using regression analysis where the monthly variations were averaged out over the span between 2001 to 2012. It showed declining trend but yielded conservative results.

The prediction was based on weighted average ratio of 3:1 between the results obtained by FFT and Time Series methods. For example in Table 1 in the year 2013 , the value of 6.886542518 as prediction was arrived at as (3 x7.25393 + 5.78438007) /4 .

The results show that in the month of June, it is projected as normal in the year 2013 but deficient in the other two projected years.

Table 2 shows that the rains are expected to be normal in these years in the month of July.

In the month of August (Table 3) , it would be deficient only in the year 2014 whereas in Table 4, it would be greater than the upper limit of the normal range in two of the three years.

The total rain values are shown in Table 5 which shows that if the total values are considered then it would be normal.

This clearly shows the fallacy in coming to the conclusion based on the total values because if the rain is deficient when the crops are planted in June, then farmers would lose their produce even if the deficient rain is made up in latter months.

6 CONCLUSIONS

In this work, at first a brief review of the drought or famine in Vidarbha area was carried out. It was found that Vidarbha has had severe drought conditions in the past.

The historical rain data showed that Vidarbha has had slight decreasing trend in rainfall (Time Series method).

At first a suitable model was searched for and it was found necessary to analyze the possible causes of the rainfall variations by looking at the frequency spectrum. The identified frequencies included the El Nino and La Nina effects amongst the others. The dominant frequencies were 3, 8, 13, 14 and 16 – mainly the higher frequencies. These higher frequencies give rise to rapid changes in rainfall about the mean value.

The rainfall predictions were made using Fourier series method and Time Series which uses Moving Average Method of rainfall and linear regression analysis. The weightage ratio of

3:1 between the two methods was selected because the FFT method fitted the actual rain data very well.

Based on this analysis, the prediction for the Year 2015 is that there will be deficient rain in planting the crops in the month of June.

5. REFERENCES

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TABLE 1 PREDICTED RESULTS FOR THE MONTH OF JUNE FOR YEARS 2013 TO 2015

JUNE	2013	2014	2015
TIME SERIES	5.78438007	5.633973	5.483565
FFT	7.25393	4.03415	4.96395
PREDICTION	6.886542518	4.434105637	5.093853755
AVERAGE	6.65305118	6.653051	6.653051
LOWER	5.38897146	5.388971	5.388971
UPPER	7.91713091	7.917131	7.917131
CLASSIFICATION	**NORMAL**	**DEFICIENT**	**DEFICIENT**

TABLE 3 PREDICTED RESULTS FOR THE MONTHS OF JULY FOR YEARS 2013 TO 2015

JULY	2013	2014	2015
TIME SERIES	10.51007216	10.23535684	9.960641525
FFT	10.8363	11.6548	12.7046
PREDICTION	10.75474304	11.29993921	12.01861038
AVERAGE	11.54564469	11.54564469	11.54564469
LOWER	9.351972195	9.351972195	9.351972195

UPPER	13.73931718	13.73931718	13.73931718
CLASSIFICATION	**NORMAL**	**NORMAL**	**NORMAL**

TABLE 3 PREDICTED RESULTS FOR THE MONTHS OF

AUGUST FOR YEARS 2013 TO 2015

AUGUST	**2013**	**2014**	**2015**
TIME SERIES	8.88189199	8.648515	8.415137
FFT	12.401	7.79356	9.91883
PREDICTION	11.521223	8.007298625	9.542906753
AVERAGE	10.9243356	10.92434	10.92434
LOWER	8.84871186	8.848712	8.848712
UPPER	12.9999594	12.99996	12.99996
CLASSIFICATION	**NORMAL**	**DEFICIENT**	**NORMAL**

TABLE 4 PREDICTED RESULTS FOR THE MONTH OF SEPTEMBER FOR YEARS 2013 TO 2015

SEPTEMBER	**2013**	**2014**	**2015**
TIME SERIES	6.02590021	5.866729	5.707558
FFT	12.1615	7.14678	11.193
PREDICTION	10.62760005	6.826767325	9.821639597
AVERAGE	6.31705217	6.317052	6.317052
LOWER	5.11681225	5.116812	5.116812
UPPER	7.51729208	7.517292	7.517292
CLASSIFICATION	**EXCESS**	**NORMAL**	**EXCESS**

TABLE 5 PREDICTED RESULTS FOR THE MONTHS OF JUNE TO SEPTEMBER COMBINED FOR YEARS 2013 TO 2015

JUNE-SEPT	**2013**	**2014**	**2015**
TIME SERIES	31.20224443	30.38457319	29.56690194
FFT	42.6538	30.6284	38.78
PREDICTION	39.79091111	30.5674433	36.47672549
AVERAGE	35.44008366	35.44008366	35.44008366
LOWER	28.70646777	28.70646777	28.70646777
UPPER	42.17369956	42.17369956	42.17369956
CLASSIFICATION	**NORMAL**	**NORMAL**	**NORMAL**

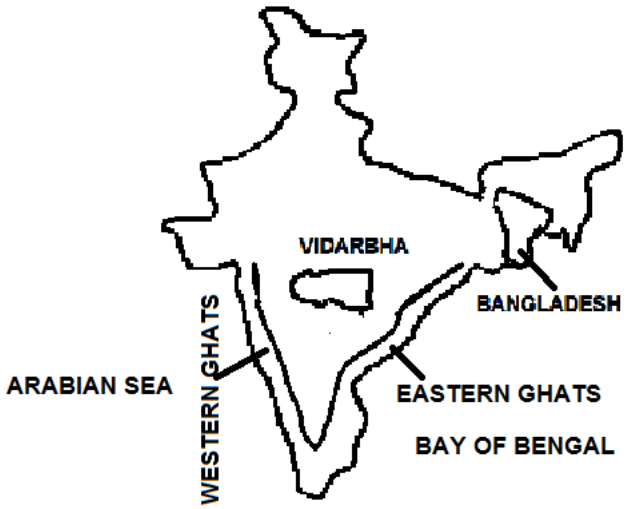

FIG. 1 LOCATION OF VIDARBHA BETWEEN EASTERN AND WESTERN GHATS

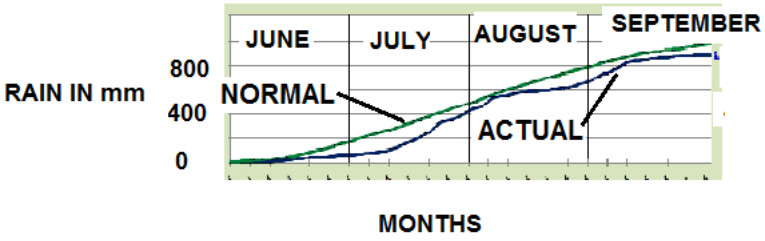

FIG. 2 RAIN IN CENTRAL INDIA IN THE YEAR 2014

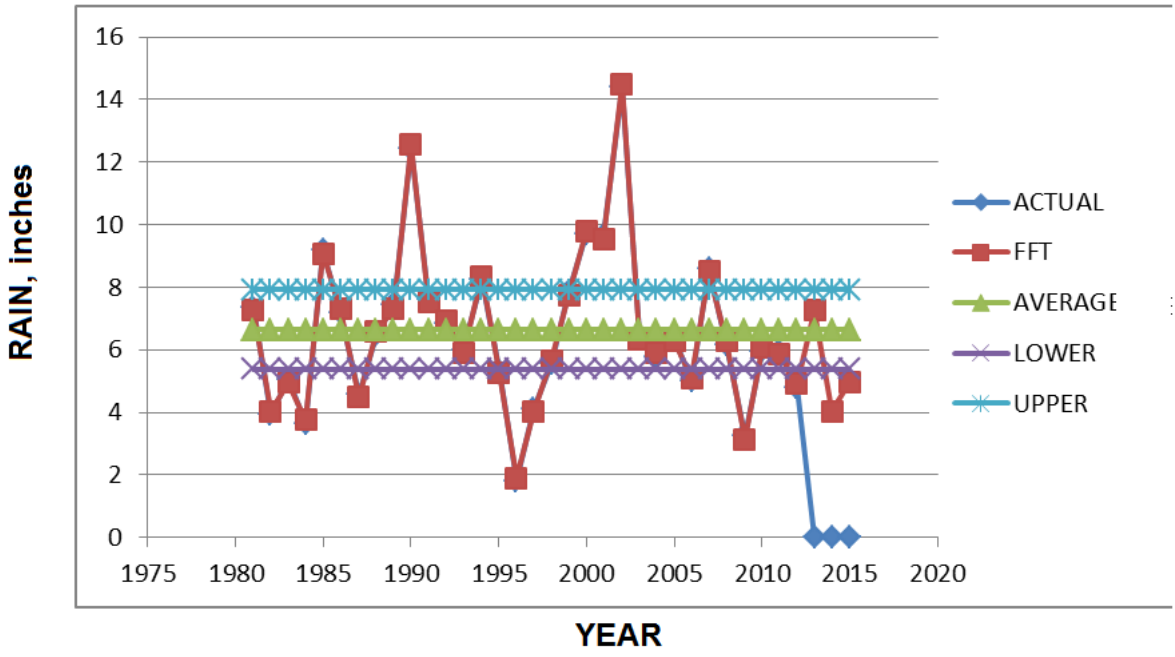

FIG. 3 RAIN IN VIDARBHA IN THE MONTH OF JUNE

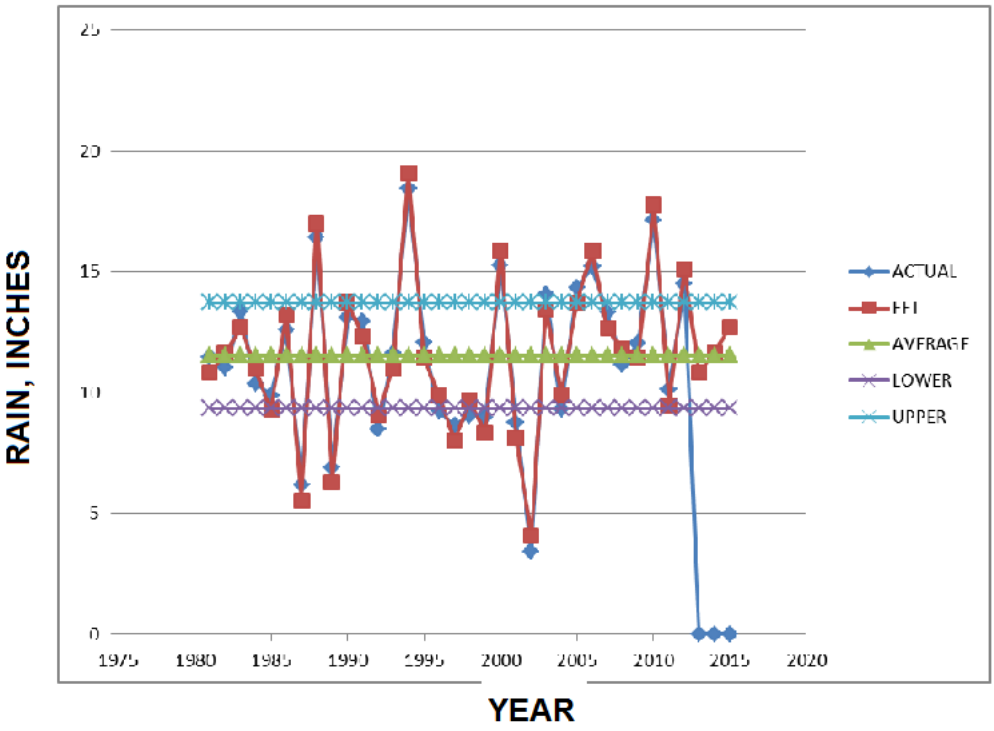

FIG. 4 RAIN IN VIDARBHA IN THE MONTH OF JULY

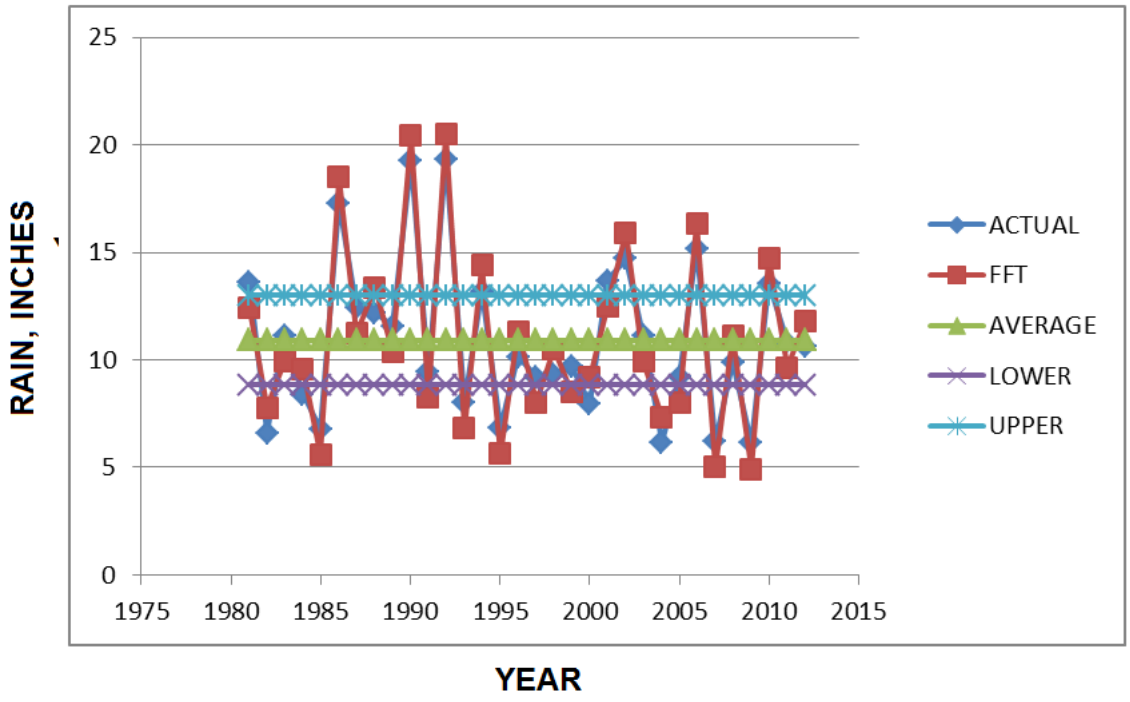

FIG. 5 RAIN IN VIDARBHA IN THE MONTH OF AUGUST

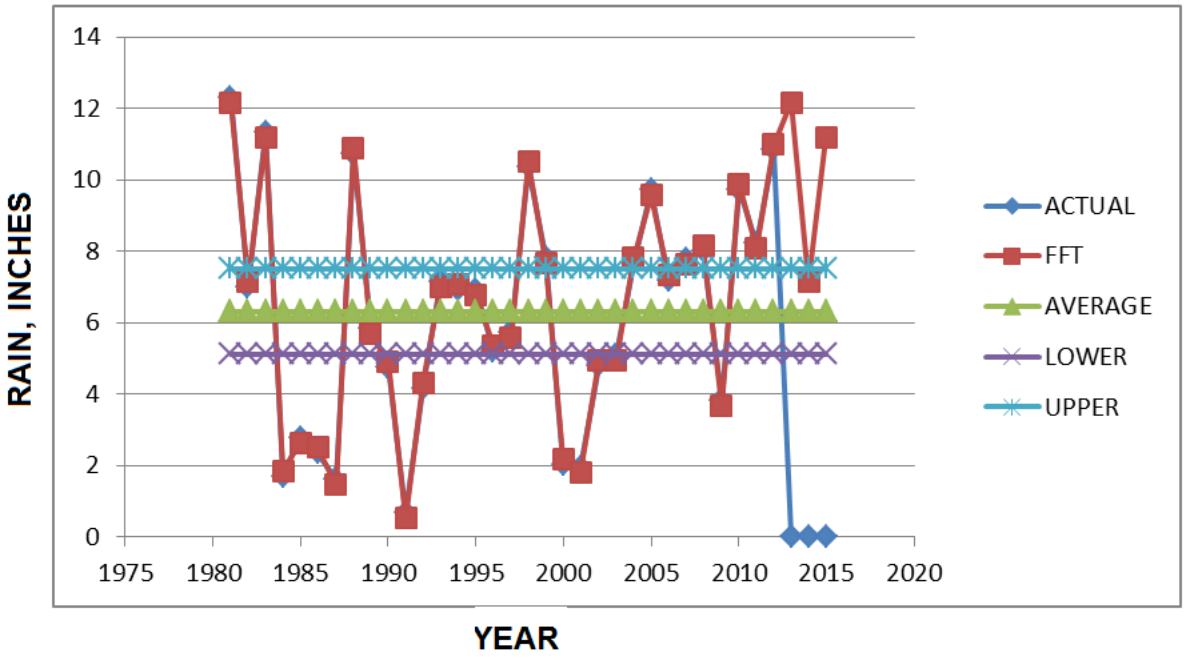

FIG. 6 RAIN IN VIDARBHA IN THE MONTH OF SEPTEMBER

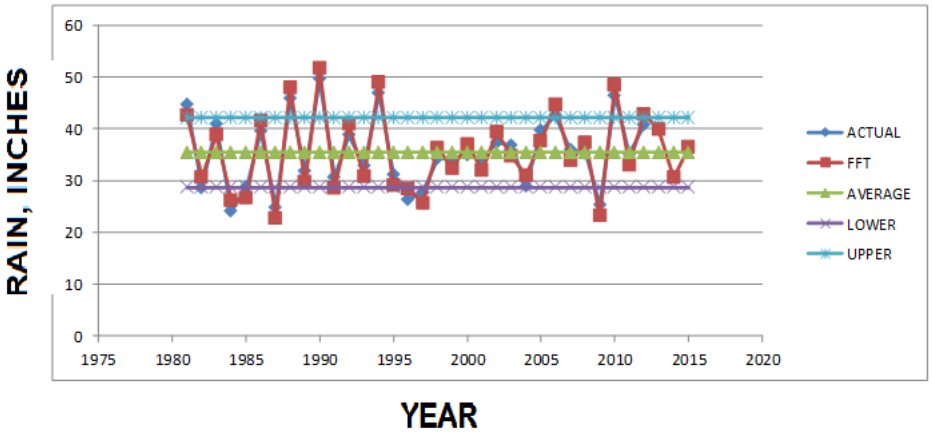

FIG. 7 RAIN IN VIDARBHA IN THE MONTHS OF JUNE TO SEPTEMBER

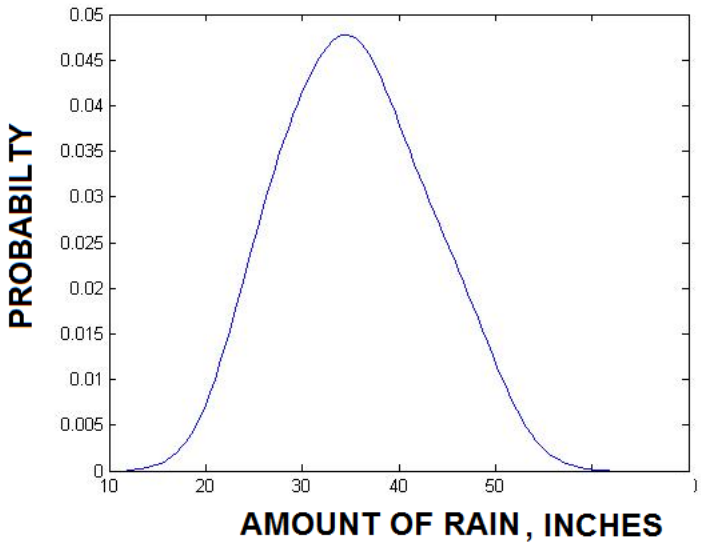

FIG. 8 PROBABILTY DENSITY FUNCTION OF RAIN BETWEEN MONTHS OF JUNE TO SEPTEMBER

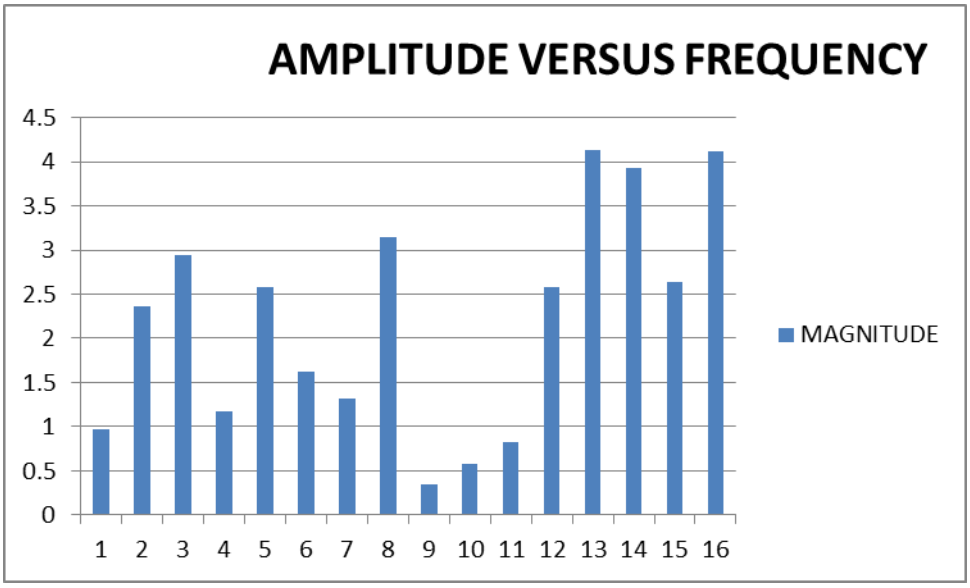

FIG. 9 AMPLITUDE VERSUS FREQUENCY DIAGRAM OF RAIN BETWEEN MONTHS OF JUNE TO SEPTEMBER