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Rainfall Prediction based on Rainfall Statistical Data

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Abstract: The paper describes the development of a system to provide information on rainfall characteristics of rainfall and its prediction from the historical data sets, and selection of crops based on the forecast on taluka basis, with a case study of Bijapur district of Karnataka State, India. The analysis of rainfall viz. month wise, *Nakshatra*-wise, week-wise and year-wise is carried out. The developed system, evolved from the analysis of 20 years' rainfall data collected from the Agricultural Research Station, Bijapur is very useful to agrometeorologists. The performance of the prediction system is encouraging and the accuracy of the prediction varies between 80% and 90%.

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INTRODUCTION

Rainfall is the most important climate variable that affects the crops in the tropical rain fed regions. People wish to know whether there would be rainfall in the coming months or year. To fulfill this requirement, one needs a forecast, well ahead of the commencement of the crop season. Such rainfall forecasts can be used both by the farmers and the Government in planning for the ensuing year. This work is an attempt to analyze the available data for development of a system for rainfall forecast and crop selection, from taluka level to state level. This work thus introduces a novel concept called region bound model for Rainfall prediction.

Rainfall is known to follow set patterns that can be explained by statistical and mathematical procedures like trend, periodicity and serial correlation. Hence it would be possible to develop appropriate models for long range forecast of rainfall. However, rainfall patterns vary within a country and within a state, in view of its high variability both temporally and spatially. We are aware, that the long range forecasts issued by the India Meteorological Department need considerable downscaling for appropriate agricultural applications. On the other hand models using the historical rainfall patterns in individual sub-regions like taluka or district can be up-scaled up to a larger area like a state or a country. This proposed model uses local speculation to global speculation approach (this, we call incremental approach). The forecast of rainfall for individual talukas of a particular district will help in guiding the district

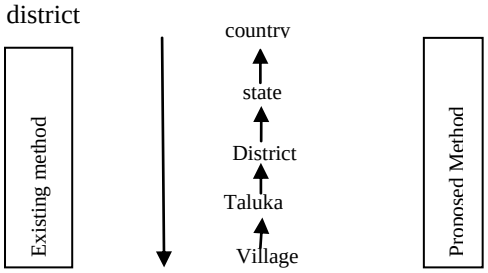

Figure 1: Incremental Model

1.0 THE PROPOSED SYSTEM

The proposed system is divided into five modules, namely: Administrator Module, Rainfall data entry Module, Predictor Module, Comparator Module and Crop Selection Module (Figure 2).

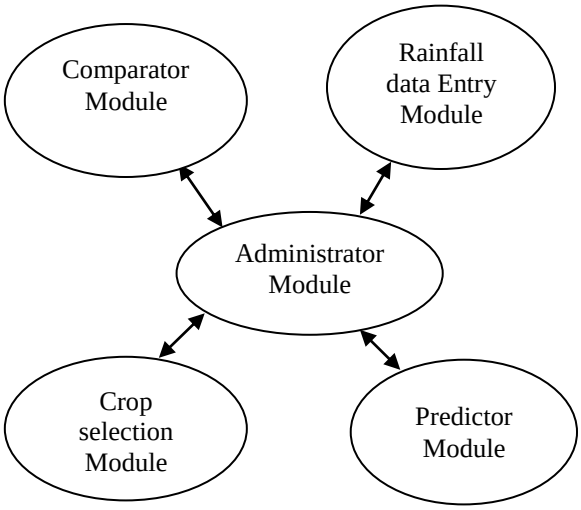

Figure 2: Functional Diagram of the proposed system

2.1 Administrator Module

This module provides the security for the data and deals with the granting of permission and revoking of users, and therefore is the vital part of the system. The administrator module takes care of user accounts, facilitates updating data, editions to crop lists, the cities and the addresses. Granting permissions to users involves the user name and the password information, which are supplied by the system administrator. Modifying of account is also done by the system administrator.

2.2 Rainfall Entry Module

The Rainfall data entries are divided into four different categories, namely, Monthly Rainfall, *Nakshatra* Rainfall, Weekly rainfall and Daily Rainfall. The entries can be made as per data availability; if daily data are entered, the data for other periods will be computed as required. Interactions in this module are given in Figure 3.

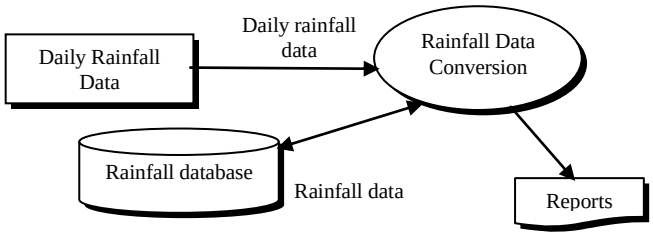

Figure 3: Rainfall data Entry Module

2.3 Predictor Module

This module uses the algorithms for the processes involving trend, serial correlation, harmonic components and autoregression analysis as mentioned earlier – with appropriate reference to Aggarwal (1992), to forecast monthly, *Nakshatra*-period and weekly rainfall. The database of the particular month or *Nakshatra* is accessed, and the data are converted into vectors. The prediction is done by using these vectors, which are input to the algorithms. These vectors are stored into a temporary database to generate reports such as graphs, charts etc. The details of the predictor module are given in Figure 4 and detailed process is given in Algorithm 1.

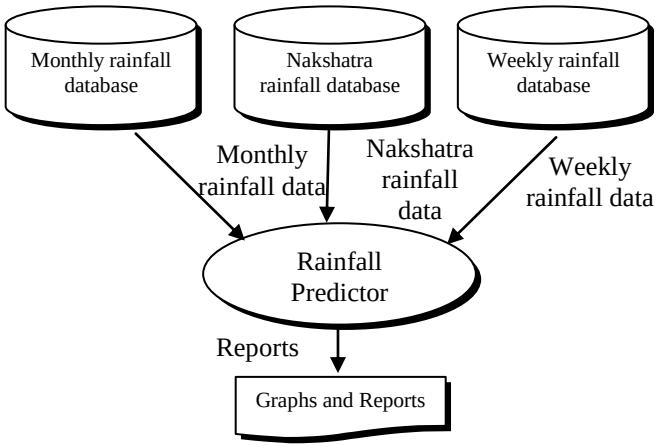

Figure 4: Predictor Module

2.4 Comparator Module

The comparator module uses the rainfall forecast and compares with the actual rainfall in a given year, i.e. year to year, month to month, week to week and *Nakshatra* to *Nakshatra*, as required by the user.

a) Year_ to_ year

This comparison takes two parameters as inputs namely, *from-year* and *to-year*. It calculates the sum of all the months' rainfall data *from-year* to *to-year* using monthly database. Finally, the average of this sum is calculated. This may be termed as mean annual rainfall, or the normal. Comparison of the annual rainfall of a selected year is made with the normal. The result is stored and displayed as per the user's requirement, as a report or graph.

b) *months to months*

In this method of prediction, three parameters are used namely, *from-year, to- year* and month. It extracts the data from the monthly rainfall database for a specified month to calculate the normal for the month. Comparison of rainfall in the month of any year is done with the normal.

c) *week to week*

In this method, weekly analysis is done in place of the monthly, mentioned above. Weekly normals are calculated and data of any year is compared with it.

d) Nakshatra to Nakshatra

In this comparison, three parameters are supplied they are *from-year, to- year* and the *Nakshatra*. This is similar to the above two, except that the procedure is for *Nakshatra* period. Comparison of rainfall is done for that particular *Nakshatra* period with the normal for the same Nakshatra period computed from the database.

e) Actual vs. Forecast

The data of estimated/forecast of rainfall and actual rainfall are extracted form the database for a given year and comparison is made. The various types of reports are generated such as Graph, charts etc. The aforesaid activities are depicted in Figure 5 and detailed process is depicted in Algorithm 2.

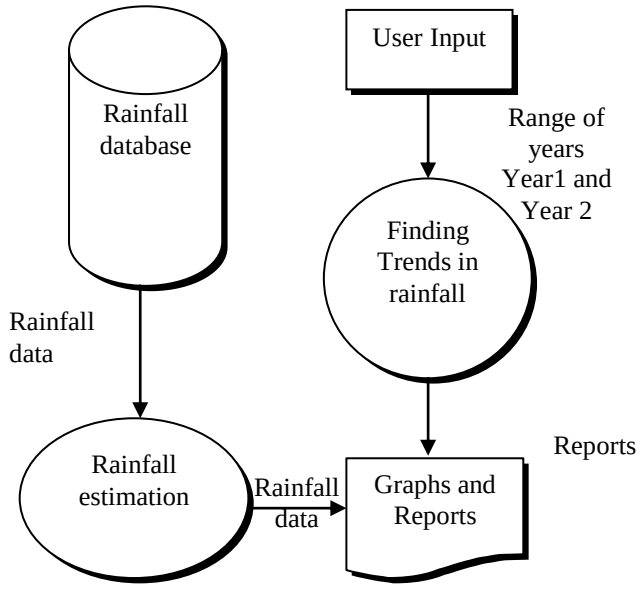

Figure 5: Comparator Module

3.0 THE ALGORITHMS

The modules are presented as different algorithms in this section. The functionality of the modules and the important operations are brought out.

Algorithm 1: Rainfall prediction
Inputs: Rainfall data.
Output: Forecasted Rainfall
Start
Step 1: Accept rainfall data from the rainfall database
Step 2: Calculate average rainfall from the rainfall data

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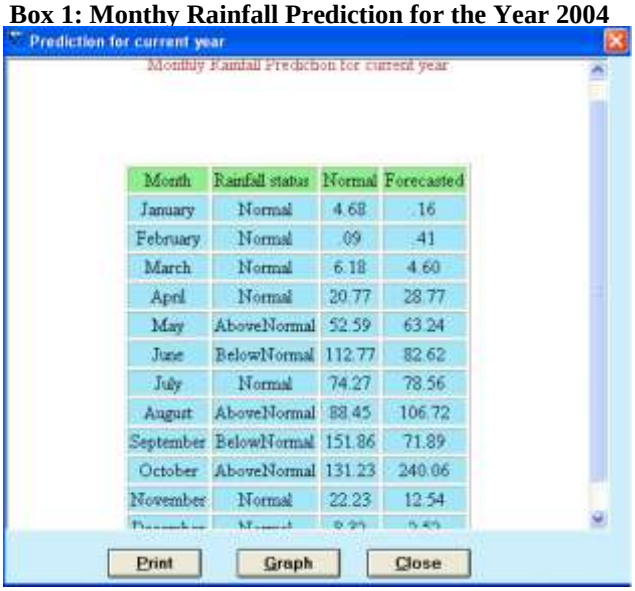
Step 3**:** Repeat Steps (3.1 to 3.4) for requested periods
Step3.1: Estimate rainfall using Linear trend
Step3.2**:** If (Estimated rainfall ≥ (Average rainfall + 10% Average rainfall))
then
Rainfall status = Above Normal
Step3.3**:** If (Estimated rainfall ≤(Average rainfall - 10% Average rainfall))
then
Rainfall status = Below Normal
Step3.4**:** If (Estimated rainfall lies between above and below normal limit)
then
Rainfall status = Normal
Step 4: Display the Rainfall status.
Stop

a) Algorithm 1: Monthly Rainfall Prediction

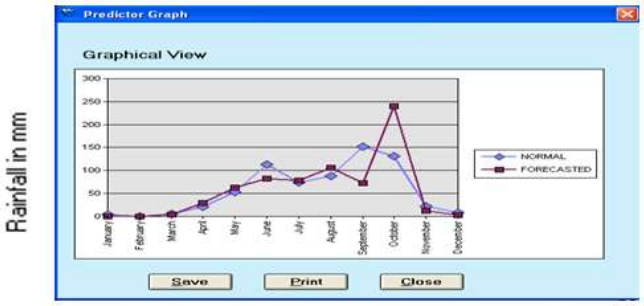
The monthly rainfall prediction algorithm forecasts the monthly rainfall, by the history of monthly rainfall data from the rainfall database. It forecasts monthly rainfall of the given year and also the subsequent years.

Box 1: Monthy Rainfall Prediction for the Year 2004



Month	Rainfall status	Normal	Forecasted
January	Normal	4.68	.16
February	Normal	.09	.41
March	Normal	6.18	4.60
April	Normal	20.77	28.77
May	AboveNormal	52.59	63.24
June	BelowNormal	112.77	82.62
July	Normal	74.27	78.56
August	AboveNormal	88.45	106.72
September	BelowNormal	151.86	71.89
October	AboveNormal	131.23	240.06
November	Normal	22.23	12.54

Box 2: Monthly Rainfall Prediction for the Year 2004



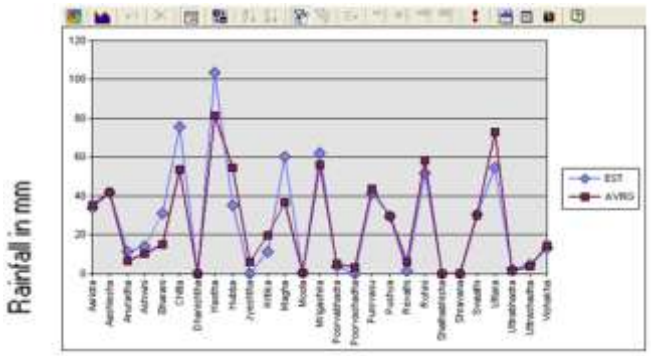
b) Nakshatra Rainfall Prediction

The Nakshatra rainfall prediction involves history of Nakshatra rainfall and forecasts rainfall of the present year and also next year.

Box 3: Nakshatra Based Prediction for the Year 2004

Nakshatra	Nakshatra Periods	Rainfall status	Normal	Forecasted
Uttrashadha	jan 10 to jan 22	Normal	3.64	4.61
Shravana	jan 23 to feb 4	Nil	.00	.00
Dhanishtha	feb 5 to feb 18	Nil	.00	.00
Shathabhisha	feb 19 to mar 3	Nil	.00	.00
Poorvabhadra	mar 4 to mar 16	Normal	5.06	3.94
Uttrabhadra	mar 17 to mar 30	Normal	1.56	2.14
Revathi	mar 31 to apr 12	Normal	6.32	1.20
Ashwini	apr 13 to apr 26	Normal	10.25	14.21
Bharani	apr 27 to may 10	AboveNormal	15.28	31.15
Krittika	may 11 to may 23	Normal	19.66	11.51
Rohini	may 24 to jun 6	Normal	58.18	51.59
Mrigashira	jun 7 to jun 20	Normal	56.14	62.30
Aardra	jun 21 to jul 4	Normal	35.14	33.83
Punrvasu	jul 5 to jul 18	Normal	43.74	41.58

Box 4: Nakshatra Based Prediction for the Year 2004

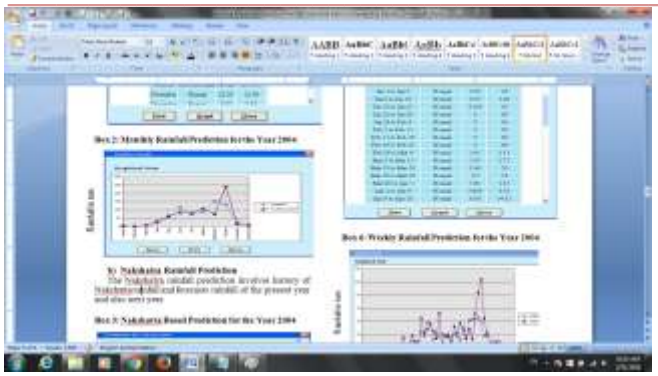


c) Weekly Rainfall Prediction

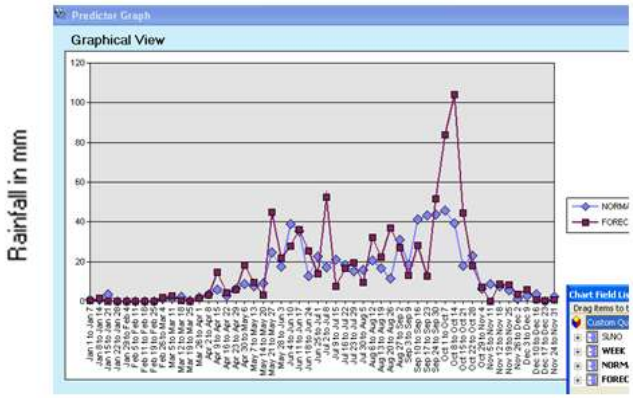
The weekly rainfall prediction section forecasts the future weekly rainfall. By extracting historical weekly rainfall data from the database, it forecasts weekly rainfall of the present year and next year.

Box 5: Weekly Rainfall Prediction for the Year 2004

Week Periods	Rainfall status	Normal	Forecasted
Jan 1 to Jan 7	Normal	0.99	29
Jan 8 to Jan 14	Normal	0.67	1.46
Jan 15 to Jan 21	Normal	3.525	10
Jan 22 to Jan 28	Normal	0	00
Jan 29 to Feb 4	Normal	0	00
Feb 5 to Feb 11	Normal	0	00
Feb 11 to Feb 18	Normal	0	00
Feb 19 to Feb 25	Normal	0	00
Feb 26 to Mar 4	Normal	1.01	2.11
Mar 5 to Mar 11	Normal	1.61	2.71
Mar 12 to Mar 18	Normal	2.46	53
Mar 19 to Mar 25	Normal	0.5	14
Mar 26 to Apr 1	Normal	1.81	1.41
Apr 2 to Apr 8	Normal	3.495	3.01
Apr 9 to Apr 15	Normal	6.06	14.51



Box 6: Weekly Rainfall Prediction for the Year 2004



d) Seasonal Rainfall Prediction

The seasonal rainfall predicts future seasonal rainfall. By the history of monthly rainfall data, it forecasts seasonal rainfall of the present year and also next year. One can specify the group of months as a season to the system.

Box 7: Seasonal Rainfall Prediction

Box 8: Seasonal Rainfall Prediction for the Year 2004

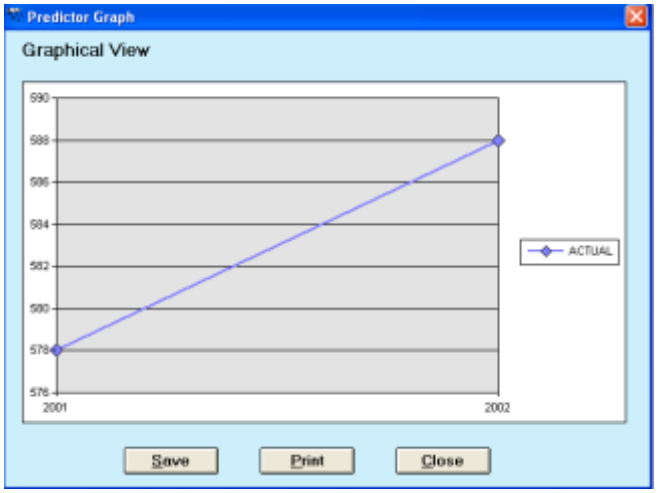
Algorithm 2: Rainfall Comparison
Input: Rainfall database
Output: Rainfall comparison
Start
Step 1: Accept the period for which data to be compared.
Step 2: Get rainfall data from the relevant database for a specified period.
Step 3: Compare the rainfall status for a given period.
Step 4: Display rainfall status as a report.
Stop

e) Yearly Rainfall comparison

The yearly rainfall is used for the analysis of annual rainfall. By the history of monthly rainfall data annual rainfall is calculated.

Box 9: Comparison of Actual Rainfall Prediction from the 2001 to 2002

Box 10: Comparison of Actual Rainfall from 2001 to 2002



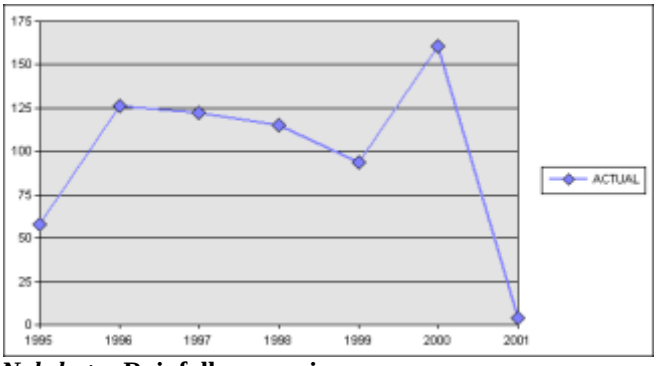
f) Monthly Rainfall comparison

The monthly rainfall comparison section gives comparative analysis of month wise rainfall. By extracting historical monthly rainfall data from the database comparison is done.

Box 11: Comparison of Actual Rainfall with Normal for the Month of June

Year	Actual	With Previous	Rainfall Status	Normal
1995	58	-	BelowNormal	112.77
1996	126	Increase	AboveNormal	112.77
1997	122	Decrease	Normal	112.77
1998	115	Decrease	Normal	112.77
1999	94	Decrease	BelowNormal	112.77
2000	161	Increase	AboveNormal	112.77
2001	4	Decrease	BelowNormal	112.77

Box 12: Graphical Presentation Actual Rainfall for June

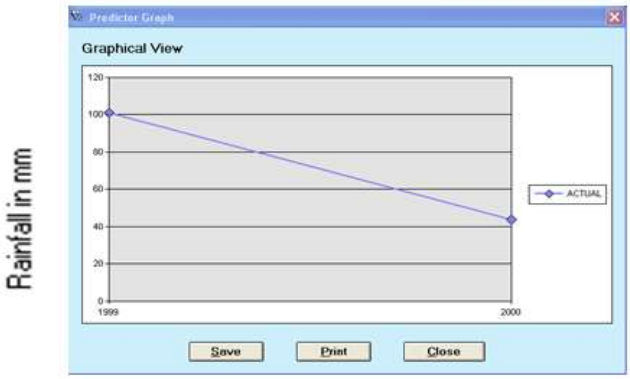


g) *Nakshatra* Rainfall comparison

The *Nakshatra* based rainfall gives comparative analysis of the Rain. By history of *Nakshatra* rainfall data is stored for the database.

Box 13: Comparison of Actual Rainfall for the *Nakshatra* "*Punarvasu*" with Previous Year

Box 14: Graphical Comparison of Actual Rainfall with Previous Year for the *Nakshatra "Punarvasu"*

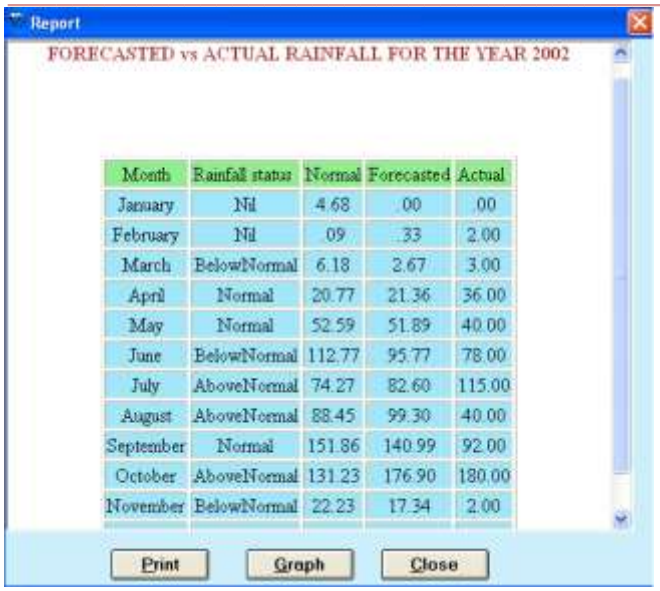


Algorithm 3: Actual v/s Forecast Rainfall Comparison
Input: Monthly Rainfall data
Output: Forecast Vs Actual Rainfall Comparison
Start
Step 1: Get monthly rainfall data available
Step 2: Calculate Average Rainfall for all the months in a year
Step 3: Accept the year from user
Step 4: Calculate Average Rainfall of the given month
Step 5: Calculate estimated Rainfall for 12 months
Step 6: Display Monthly Rainfall data, Average Rainfall data and Estimated Rainfall
Stop

h) Forecast vs Actual Rainfall Comparison

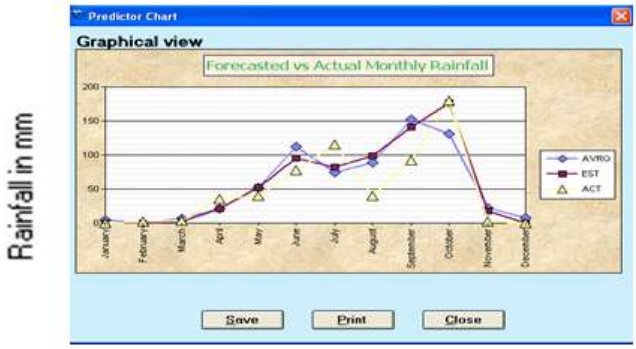
The forecast vs actual rainfall comparison section gives comparative analysis forecasted rainfall and actual rainfall. By extracting historical monthly rainfall data from the database comparison is done.

Box 15: Forecasted Vs Actual Rainfall for the Year 2002



Month	Rainfall status	Normal	Forecasted	Actual
January	Nil	4.68	00	00
February	Nil	09	33	2.00
March	BelowNormal	6.18	2.67	3.00
April	Normal	20.77	21.36	36.00
May	Normal	52.59	51.89	40.00
June	BelowNormal	112.77	95.77	78.00
July	AboveNormal	74.27	82.60	115.00
August	AboveNormal	88.45	99.30	40.00
September	Normal	151.86	140.99	92.00
October	AboveNormal	131.23	176.90	180.00
November	BelowNormal	22.23	17.34	2.00

Box 16: Graphical comparison of Forecast and Actual Rainfall for the Year 2002



3.0. CONCLUSION

A methodology for analyzing the historical rainfall data of monthly and *Nakshatra* periods is developed for their long range forecast one season ahead. This system is useful for not only for forecasting, but also for analytical comparison with the past data. Regional data is used in the analysis, which is considered to be a novel approach for forecast and up-scaling to state level.

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