Comparative Analysis of Prediction Model In Weather Forecasting System For Agricultural Development

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Abstract. Agriculture is the backbone of a country. If a country is able to yield very good food it can be one of the best countries in the world. Rainfall is playing a vital role in field of agriculture. Predicting weather conditions for agriculture is a challenging and most needed feature for agriculture for every country. In the recent years, Data Analytics has played a vital role in detecting the challenges and risks in certain factors. We use Learning algorithms to predict challenges and risk faced in each problem. By predicting them in prior we may take certain actions before itis leaving out of our hand. The learning and prediction algorithms help to classify, predict and to make changes if needed. This study aims in predicting weather (i.e., Rainfall) which helps every agriculturist to predict weather and to sow different types of plants based on the weather condition. This study not only helps for agriculture it also helps in various fields like fishing, sports, transportation, tourism, etc. Weather forecasting is based on the available historical data. The predictions are done using various algorithms like Artificial Neural Network (ANN), Support Vector Machine (SVM) and Linear Regression (LR). The results infer that the prediction model using Support Vector Machine gives the best accuracy when compared with Linear Regression and Artificial Neural Network. This prediction helps people in planting crops and helps to make decision based on the weather condition.

Keywords: Weather prediction, Agriculture, Learning models, Support Vector Machine, Linear Regression, Artificial Neural Network..

1 Introduction

Agriculture plays an important role in one's country economic growth and it is a must needed for living beings and even for the world it is necessary to save its nature. Predicting rainfall for agriculture is important to maintain the food stock and supply. It is very important to predict the climate change for agriculture purpose. Rainfall prediction is to predict the changes in the atmospheric condition for a location and time. We predict rainfall based on the collected data and state of the atmosphere for a given place and using meteorology techniques. we must predict the most accurate results for predicting rainfall since we get the new updated results each time.

Predicting rainfall for agriculture is fundamentally important to people who sow or plant the seeds based on the climate changes. They may sow different seeds based on the climate predicted and soil they have. Agriculture is backbone of a country it contributes nearly half of the country's income. Predicting rainfall is not only used for agriculture purpose it is used for multi-purpose and for multi-people. Predicting rainfall will be able to take the precautionary measures. It will be used in various fields like agriculture, fishing, sports, transportation, tourism, etc. In the recent times, Data Analytics has boomed into action in all fields improving

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the standards of living by providing prediction techniques and risk assessment. It helps us to predict rainfall and people for agriculture. Machine Learning is part of Data Analytics that renders various algorithm for classification, regression and risk assessment. Predicting the rainfall to benefit the people in various fields and to keep stock or to ship the foods [6-9].

The objective of this article is for predicting rainfall using the various Machine Learning techniques. The prediction models like Artificial Neural Network, Support Vector Machine, Linear Regression are used and their results are compared. The predicted results will be useful for agriculturist in cultivating crops. The paper is constructed as, Related study in section 2 and section 3 describes the Indian Meteorological department dataset used. Section 4 discusses about the prediction models for predicting rainfall followed by section 5 which discuss the performance metrics suitable for evaluating the models for predicting rainfall. Section 6 compares and analyses the results obtained by the classifiers followed by conclusion in section 7.

2 Related Work

Wenying et al., [1] presented a weather prediction model based on a linear Support vector machine for training multiclass classifiers. Although Support vector machine is appropriate for categorization, its classification findings are extremely dependent on the kind of kernel, soft margin coefficient and kernel parameters all of which are hard to identify. In the study, the method called particle swarm optimization technique was used to improve these parameters in the hopes of achieving high prediction results. The results of the predictions suggest that this strategy is both possible and effective.

N. DivyaPrabha al., [2] presented a technique for enhancing Multilayer Perception, where the network model is being developed as a mean for forecasting rainfall time series. The proposed Multilayer Perceptron Neural Network was used to approve this Rainfall Data series. In comparison to other networks such as AdaSVM and AdaSVM, it appears that the presenting method such as Normalized Mean square error and Mean square error on testing and data set preparation for small term forecast are determined to be the best feasible.

S. Prabakaranal.,[3] By iterating and adding some percentage of error to the input data, a linear regression method was proposed to be adjusted in order to acquire the most ideal error percentage.This approach predicts rainfall based on many climatic data such as the cloud cover and the average temperature. On the datasets, linear regression is applied, and coefficients are utilised for rainfall prediction based on the parameters values. The key benefit of this model is that it calculates rainfall based on prior correlations between various atmospheric factors. As a result, a rough estimate on the rainfall would be certain time and location can be easily discovered.

Sanyam Guptaal.,[4] To forecast the weather based on a few characteristics, researchers used machine learning algorithms, a regression model using two optimization approaches and statistics. the Gradient descent method and Normal equation method. The performance of algorithms was compared using two optimization strategies. The results showed the normal technique anticipates the high degree of precision weather, but the gradient descent method forecasts the weather with a low degree of precision.

DiresNegashFente et al., [5] suggested a weather forecasting system for determining the correct values of weather parameters as well as predicted weather conditions depending on

these parameters. Diverse meteorological parameters are received from national climate data centre, and the neural network was trained across various variations using the Long-short term memory (LSTM) approach. The weather parameters utilised include Humidity, Pressure, wind speed, temperature, dew point visibility and precipitation. The forecasting of future weather is done once the LSTM model has been trained using these parameters.

Kumar et al., [10] presented an ANN as a viable approach for revealing structural relationships between different entities. The study developed effective and trustworthy nonlinear prediction models to examine the applicability of the ANN technique for weather analysis. It also analyses and assesses the effectiveness of model building using various neurons, hidden layers, and transfer functions to anticipate min and max temperatures everyday in the year. For the Udupi district of Karnataka, India, they built an Network model to anticipate average monthly rainfall. A rainy season in Udupi is from April to November, with the primary monsoon periods being May to October. As a result, they looked at the data from these eight months from 1960 to 2010. Finally, three multi-layer architectural methods were compared: Layer Recurrent Network (LRN), Cascaded Back-Propagation (CBP) and Back Propagation Algorithm (BPA) with the authors concluding that BPA is the best of the three.

M. S. Bennet Praba al., [11] suggested system of sophisticated weather monitoring solution that makes actual data easily available across a large area via IoT. Using various sensors, the system tracks weather and climatic changes such as UV radiation, light intensity, wind speed, humidity, temperature, wetness and even carbon monoxide levels in the air. The cloud data is then categorised using the Support Vector Machine technique to forecast whether or not it will rain. Meteorological offices, weather stations, the aviation and maritime sectors, and even the agriculture business can benefit greatly from this research.

Temporal Delay Neural Network (TDNN), Elman Partial Recurrent Neural Network (Elman) and Multilayer Feed Forward Neural Neural Network (MLFN) have been created and compared for rainfall prediction (TDNN) by Luk et al. [12] and Abraham et al.[21] employed four soft computing algorithms to forecast rainfall time series: General Regression Neural Network (GRNN), Adaptive Basis Function Neural Network (ABFNN), Evolving Fuzzy Neural Network (EfuNN), and ANN utilising Scaled Conjugate Gradient Algorithm (ANNSCGA). They employed Multivariate Adaptive Regression Splines (MARS), which is an a approach based on regression that leverages the certain class of the basis functions as predictors. The training model for this study used monthly rainfall as data input. The researchers used the kerala state rainfall data, which is in the southern region of the Indian Peninsula, over 87 years. The empirical findings indicate the neuro fuzzy systems seem to be more effective in terms of performance time and error rates than pure neural network techniques. Despite this, rainfall is among the 20 most complicated and challenging parts of the hydrological cycle to comprehend and predict because to the enormous variety of variance across a wide range of spatial and temporal dimensions.

Chistodoulou et al. [13] developed a method for predicting rainfall rate employing weather radar rather than rainfall data on the land. With input data as radar and the output as the rain gauge measurements, the statistical KNN classifiers and the neural SOM were employed for the classification job. The ground rainfall rate was anticipated using radar reflections has an average error rate of 23%. Finally, discovered the rainfall rate prediction using weather radar readings is achievable.

Based on the area weighted value of all district forecasts, Guhathakurta[14]developed an ANN model to predict the monsoon rainfall of the districts of Kerala state and their sub-divisions. Finally, they identified that the performance of the model is found to be enhanced than statistical approach.

On the basis of historical findings, Somvanshi et al. [15] presented a methods to modelling and forecasting the behavioural pattern in rainfall events. They developed two fundamentally distinct methods to model design: a statistical strategy based on computationally powerful techniques based on ANN and autoregressive integrated moving average (ARIMA).

For rainfall prediction, Xiniaet al.[16]have suggested a novel model which is been based on RBFN and empirical mode decomposition (EMD). They found that the approach was highly accurate in denoising and predicting the rainfall sequence after simulation.

A Rainfall Runoff Prediction Using Artificial Neural Networks in a Study Case on the Jarahi Watershed [17] found that the Artificial Neural Network technique is more suited and efficient for predicting river runoff than the traditional regression model.

A Multilayer Perceptron Neural Network was proposed by Deshpande [18] as just an intelligent tool in forecasting Rainfall Time Series. Rainfall samples were collected at Yavatmal, Maharashtra, India, at a government-approved rainfall monitoring site. The suggested Multilayer Perceptron Neural Network was used to provide multi-step forward predictions for this Rainfall Data series. In contrast to other networks such as the Jordan Elmann Neural Network, SOFM and RNN, and found the performance metrics as Mean square error and Normalized mean square error on testing as well as training data set for short term prediction were ideal (Recurrent neural network).

Chau et al. [19] used a variety of soft computing techniques to predict rainfall. They looked at two factors to increase rainfall forecast accuracy: (I) using a data pretreatment strategy, (II) using modular modelling technique. Two of recommended methods of preprocessing were Singular spectrum analysis (SSA) and moving average (MA). The modular models are built up of local SVR or local ANN models. The Neural network model is being used to pick between MA and SSA for data preparation. Finally, they demonstrated that the MA outperformed the SSA when combined with the ANN.

Singh et al., [20] used feed forward back propagation network learning model to estimate Indian Summer Monsoon Rainfall (ISMR). They suggested an a 5 neural network designs BP1, BP2, BP3, BP4, BP5 employing with the three layers of neurons based on this technique. Each neural network architecture (BP1–BP5) was trained and evaluated individually on the data set. After that, the predicted outcomes for the training and test sets are compared to the current model. The proposed method's results show that their model outperforms the currently used model. The estimates of Seasonal rainfall for the following 5 years are also forecasted for India.

Karmakar et al. [21] proposed an a 3 layered probabilistic artificial neural network and sensory feed forward back propagation deterministic model to forecast long range monsoon rainfall across EPMB subdivisions. Data was collected from 1945 to 2006, with the first 51 years (1945-1995) being used in the network training while the other years (1996–2006) being utilised for validation. However, they discovered that the model's efficiency in probabilistic forecasting was higher to deterministic forecasting.

3 Dataset Description

Two Indian Meteorological department datasetsare taken for rainfall occurring within India. The first Indian Meteorological department dataset contains district rainfall normal (in mm) monthly, seasonal and annual. The Indian Meteorological department dataset is available for the period 1951 to 2000. This information pertains to the climatological normal of district-level

rainfall (in millimetres) for the period (1951 to 2000). It's made public as part of the National Data Sharing and Accessibility Policy (NDSAP). Ministry of Earth Sciences India Meteorological Department is a contributor (IMD).

For the second Indian Meteorological department dataset we have district wise details which is similar to the number of attributes is same as first Indian Meteorological department dataset but the year is not available in this first Indian Meteorological department dataset. The amount of rainfall in mm for each district is added from 1950 to 2000.

Subdivision-wise Rainfall and its Departure from 1901 to 2015 are available in the Indian Meteorological Department dataset 2. It is possible to collect month-by-month rainfall statistics for all of India. The data includes sub-division-by-subdivision rainfall and deviations from normal for each month and season. It was made public in accordance with the NDSAP. The Ministry of Earth Sciences' India Meteorological Department donated it (IMD).

Dataset 2 of the Indian Meteorological Department comprises of Nineteen characteristics and the thirty six sub divisions. Data is from 1950 to 2015 for some of the sub-divisions. The total quantity of rainfall in mm is present in all characteristics.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	STATE/UT	DISTRICT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	JAN+FEB	MAM	JJAS	OND
2	ANDAMAN And	NICOBAR	107.3	57.9	65.2	117	358.5	295.5	285	271.9	354.8	326	315.2	250.9	2805.2	165.2	540.7	1207.2	892.1
3	ANDAMAN And	SOUTH ANDAMAN	43.7	26	18.6	90.5	374.4	457.2	421.3	423.1	455.6	301.2	275.8	128.3	3015.7	69.7	483.5	1757.2	705.3
4	ANDAMAN And	N & M ANDAMAN	32.7	15.9	8.6	53.4	343.6	503.3	465.4	460.9	454.8	276.1	198.6	100	2913.3	48.6	405.6	1884.4	574.7
5	ARUNACHAL PRA	LOHIT	42.2	80.8	176.4	358.5	306.4	447	660.1	427.8	313.6	167.1	34.1	29.8	3043.8	123	841.3	1848.5	231
6	ARUNACHAL PRA	EAST SIANG	33.3	79.5	105.9	216.5	323	738.3	990.9	711.2	568	206.9	29.5	31.7	4034.7	112.8	645.4	3008.4	268.1
7	ARUNACHAL PRA	SUBANSIRI F.D	28	48.3	85.3	101.5	140.5	228.4	217.4	182.8	159.8	75.9	20.9	11.6	1300.4	76.3	327.3	788.4	108.4
8	ARUNACHAL PRA	TIRAP	42.2	72.7	141	316.9	328.7	614.7	851.9	500.6	418.3	218.7	42.9	22.9	3571.5	114.9	786.6	2385.5	284.5
9	ARUNACHAL PRA	ANJAW (LOHIT)	42.2	80.8	176.4	358.5	306.4	447	660.1	427.8	313.6	167.1	34.1	29.8	3043.8	123	841.3	1848.5	231
10	ARUNACHAL PRA	LOWER DIBANG	83.7	153.9	303.5	383.6	268	374.2	272	160.5	266.7	167.2	64	56	2553.3	237.6	955.1	1073.4	287.2
11	ARUNACHAL PRA	CHANGLANG	70.3	170.9	367.9	554.4	334.2	526.2	460.8	291.5	353.6	275	64.9	74.2	3543.9	241.2	1256.5	1632.1	414.1
12	ARUNACHAL PRA	PAPUM PARE	33.5	67.8	106.1	226.9	453	640.5	609.5	503.4	492.3	214.7	19.2	11.3	3378.2	101.3	786	2245.7	245.2
13	ARUNACHAL PRA	LOW SUBANSIRI	97.5	109.3	92.4	204.3	266.2	284.1	248.9	270.5	192.7	78.5	49.5	27.2	1921.1	206.8	562.9	996.2	155.2
14	ARUNACHAL PRA	UPPER SIANG	74.3	176.7	362.6	397.5	408.7	801.9	653	417.9	686	264.9	86.9	71.7	4402.1	251	1168.8	2558.8	423.5
15	ARUNACHAL PRA	WEST SIANG	26	66.7	76.8	229.2	239.5	416.6	592.4	312.4	291.1	126.8	33.7	29.5	2440.7	92.7	545.5	1612.5	190
16	ARUNACHAL PRA	DIBANG VALLEY	83.7	153.9	303.5	383.6	268	374.2	272	160.5	266.7	167.2	64	56	2553.3	237.6	955.1	1073.4	287.2
17	ARUNACHAL PRA	WEST KAMENG	35.2	43.5	58.9	134.3	341.1	665.3	749.9	579.1	490.9	233.9	40.3	27	3399.4	78.7	534.3	2485.2	301.2
18	ARUNACHAL PRA	EAST KAMENG	49	74.4	96.5	156.9	208	345.7	368.5	256.2	275.9	138.2	34.4	27.2	2030.9	123.4	461.4	1246.3	199.8
19	ARUNACHAL PRA	TAWANG(W KAME	35.2	43.5	58.9	134.3	341.1	665.3	749.9	579.1	490.9	233.9	40.3	27	3399.4	78.7	534.3	2485.2	301.2
20	ARUNACHAL PRA	KURUNG KUMEY	82.7	70	128.2	245.7	271.4	292.7	404	276.3	283.5	92.3	32.3	42.4	2221.5	152.7	645.3	1256.5	167
21	ASSAM	CACHAR	13.3	50.2	168.3	262.5	386.4	532.1	526.2	470.8	360.8	182.4	34.8	11.4	2999.2	63.5	817.2	1889.9	228.6
22	ASSAM	DARRANG	13.1	21.4	53.5	168.8	320	419.7	345.8	272.1	221.5	95.4	17.2	9.3	1957.8	34.5	542.3	1259.1	121.9
23	ASSAM	GOALPARA	12.7	20.4	51.1	196.6	399.8	567.8	502.8	334.6	304.9	157.7	21.7	5.2	2575.3	33.1	647.5	1710.1	184.6
24	ASSAM	KAMRUP	12	20.8	58.6	151.7	293.4	365.5	345.1	248.7	188.4	106.6	15.1	7.5	1813.4	32.8	503.7	1147.7	129.2
25	ASSAM	LAKHIMPUR	27.7	48.6	76.7	165.5	331.9	528.3	605.2	467.6	424.1	140.3	23	20.4	2859.3	76.3	574.1	2025.2	183.7
26	ASSAM	NORTH CACHAR	16.7	47.5	158.9	207.9	308	328.1	270.3	201.3	189.1	196.4	42.1	11.2	1977.5	64.2	674.8	988.8	249.7

Fig.1. Sample view of dataset of district wise rainfall

4 Predictiom Models

4.1 Support Vector Machine (SVM)

It is a learning model which is classified as the supervised learning model for two-group classification problems, that employs classification techniques. SVM models can also categorize fresh text after being given sets of labelled training data for each category.

4.2 Linear Regression (LR)

This is an a learning methodology categorized as supervised which has an a constant slope and the continuous projected output. It is used to forecast values within a continuous range rather than categorising data into groups.

4.3 Artificial Neural Networks (ANN)

This model is being motivated by the human brain structure. It is essentially an a learning model based on unsupervised learning. It is a network of connected things known as nodes, each of which is in charge of performing a basic calculation.

5 Performance Metrics

5.1 Accuracy

Accuracy is used as the performance metrics for the crop yield prediction system since true positives and true negatives are more significant in the prediction of yield. Accuracy is the number of correctly predicted data entries among all the data entries. The no of correctly predicted data entries corresponds to the sum of all the true negatives and true positives as shown in Eq (1).

$$\text{Accuracy} = \frac{(\text{TP}+\text{T}\ )}{(\text{TP}+\text{TN}+\text{FP}+\text{F}\ )} \quad (1)$$

Where, True Positive(TP), False Positive(FP) , True Negative(TN), False Negative(FN).

5.2 Heat Map

It is a visual duplication of data with color coded values. It will make it a very ease to view large amounts of data. The data for a heat map is collected from a web page. It displays which content is utilised more frequently using a dark-to-light colour scale.

5.3 Confusion Matrix

Confusion matrix compares the actual target values with the predicted values and measures the performance of the classifier. It evaluates the parameters like true positives, true negatives, false positives and false negatives which are useful in visualizing important predictive analytics.

6 Results Analysis

The Table 3. Shows the Mean Absolute Error (MAE) obtained for the prediction models. The results indicate that artificial neural network outperform other models, with the SVM Classifier having the worst performance. Rather of learning distinct patterns from all states, we chose Andhra Pradesh, which has a single pattern that can be learnt by models. As a result, it is extremely precise. The following table 1 gives the result of the prediction models and the visual representation of the comparison of result of model used for comparison is shown in Fig.2.

Prediction Models	Mean Absolute Error
Support Vector Machine	89.06 %
Linear Regression	54.16 %

Artificial Neural Network	42.77 %

Table 1. Training on complete indian meteorological department dataset

It is observed from the results that the rainfall distribution over years and it is seen that the highest rainfall is obtained on 1950. Fig 3 represents the graph for the distribution of rainfall over years with the X Axis represent years while the Y axis denotes the amount of rainfall.

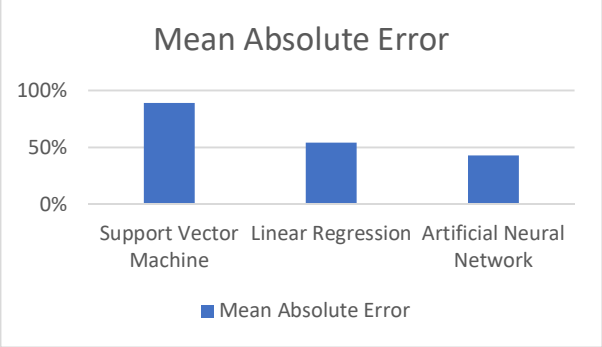

Fig.2. Mean absolute error comparison of prediction models

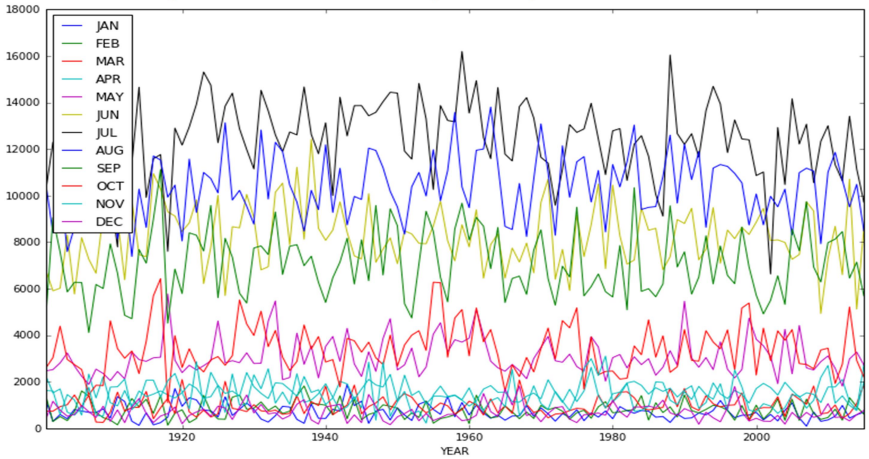

Fig.3. Distribution of rainfall over years

Then there are the observed findings for the graph that depicts the rainfall distribution over months. The amount of rain is highest in the months of July to September, which is India's monsoon season. Fig 4 gives the distribution of rainfall over year month wise with the X-axis denotes the amount of rainfall over the year month wise and Y-Axis denotes the various subdivision of various districts..

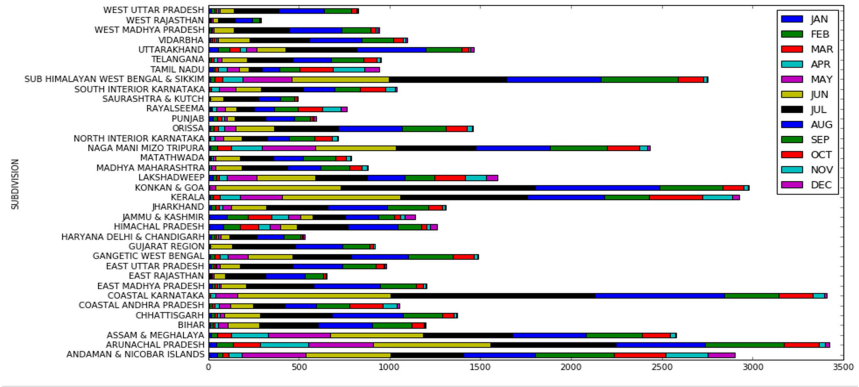

Fig.4. Distribution of rainfall over year district wise

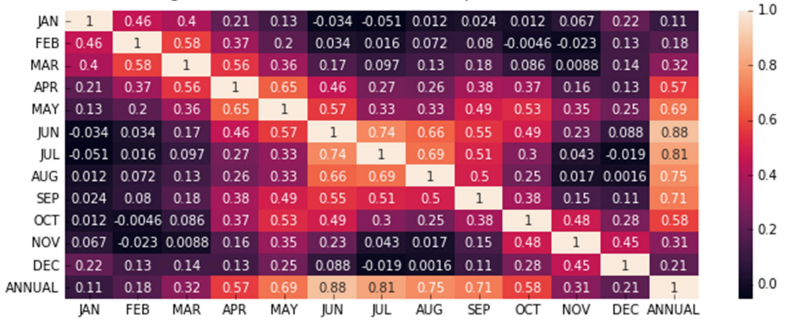

Fig.5. Heatmap for distribution of rainfall

Fig 5 shows the heat map for the amount of rainfall. The heat map shows the amount of rainfall is reasonably good in the months of March, April, May in eastern India.

Fig 6 will give the rainfall for each district. This shows the graph which depicts the distribution of rainfall for each district. This is beingdone for 40 districts alone with the X-axis denotes the amount of rainfall over the year month wise and Y-Axis denotes the various districts.

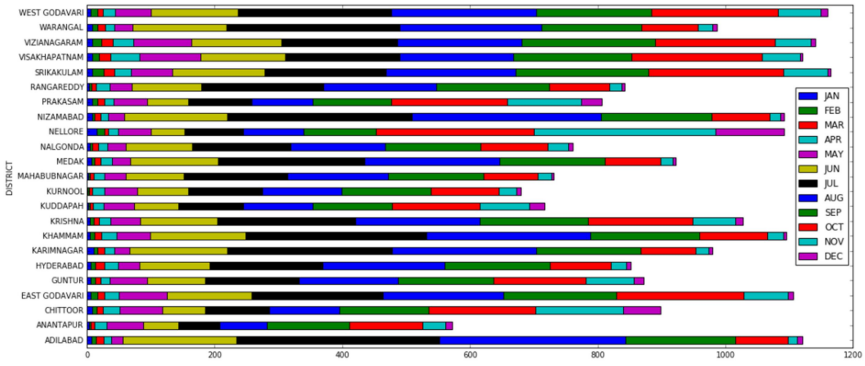

fig.6. graph for distribution of rainfall over districts

4. 7. Conclusion

This paperprovides an overview of various work carried out in the field of weather prediction and also implements and compares rainfall prediction model for agriculture. Also,a related study was made for the project and have implemented with the three Machine Learning models. From that we have obtained the better results for neural networks than the other model. This work will help people whose lives depend on rainfall mainly for agriculture purpose. This work can be extended for other countries as well and come up with the better accuracy than we have obtained now.

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