

Original Research Article

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District Wise Usability Analysis of Rainfall Forecast in North Gujarat, India

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ABSTRACT

District wise medium range weather forecast on rainfall issued from India Meteorological Department (IMD), New Delhi for Banaskantha, Gandhinagar, Mehsana, Patan and Sabarkantha district was compared with actual rainfall collected from Gujarat State Disaster Management Authority website during monsoon 2015 to 2020 to assess its reliability and accuracy. Various criteria like usability, RMSE, H.K. Score and Ratio Score were used to verify the accuracy of rainfall forecast. The results revealed that the accuracy of rainfall forecast was good and satisfactory for all the districts during the year 2015, 2016, 2017 and 2018 while, the accuracy was poor in the year 2019 and 2020. However, the mean accuracy over six year period varied in between 63.10 to 70.01% in different districts. The mean value of RMSE ranged from 19.36 to 23.46 in different districts. Similarly, the mean values of H.K. Score and Ratio Score varied in between 0.38 to 0.47 and 68.27 to 74.07 respectively in different districts which indicated success of rainfall forecast.

Keywords

Rainfall, Usability, Ratio score, HK Score

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Introduction

Indian agriculture depends on rainfall activity and the associated weather phenomenon during south west monsoon. Each and every phase of agricultural activity from sowing to harvesting is directly or indirectly influenced by weather condition. The healthy growth and yield of crops depend upon certain optimum conditions of weather with which the plant

growth is concerned (Ramdas, 1996). The weather forecasting helps farmers in capitalizing benevolent weather conditions in order to optimize the resource use and to minimize the loss due to aberrant weather conditions (Rathod *et al.*, 2003). In arid to semiarid climate, rainfall is the major influencing climatic factor which determines the crop production in *kharif* season in India. Rainfall in south west monsoon season is the

most important weather elements as the country's agricultural production is dependent on its amount and distribution (Rao *et al.*, 1999). An accurate weather forecast not only helps in increasing agriculture production and quality of produce but helps in efficient use of limited resources. Forecast of onset of monsoon is therefore important for sowing and different crop management practices during *kharif* season. High rainfall, low radiation and high pest incidence are detrimental to high crop production (Chatterjee and Mandal, 1988). The degree of vulnerability of crops to climate variability depends mainly on the development stage of the crops at the time of weather aberration (Lansigan *et al.*, 2000). The negative impact may be partially reduced if the occurrence of the weather events is predicted in advance and farmers are suitably advised to take ameliorative measures. Timely and accurate weather forecast helps to farmers realize the potential benefits using weather-based agrometeorological information in minimizing the losses due to adverse weather conditions. The reliability and accuracy of rainfall weather forecast were analysed by several workers (Tripathi *et al.*, 2008; Chauhan *et al.*, 2008; Lunagaria *et al.*, 2009; Chaudhry *et al.*, 2010; Khichar *et al.*, 2010; Mishra *et al.*, 2010; Das and Desai, 2018; Sakarkar *et al.*, 2018 and Ray *et al.*, 2019) for different Agro climatic zones of India. Medium-range weather forecasts on rainfall play a significant role in making short-term adjustments in daily agricultural operations during monsoon. Therefore, an attempt has been made to analyse and verify the district wise rainfall forecast of North Gujarat.

Materials and Methods

North Gujarat agro climatic zone lies between 23.4° N and 24.7° N latitude and 71.9° E to 73.9°E longitude, having tropical semiarid to arid climate. Most of the rainfall in the region

received during south west monsoon season with uneven distribution and high variability. Under Gramin Krishi Mausam Seva (GKMS) scheme at Agromet Field Unit, Dantiwada (Gujarat), the district wise rainfall forecast for Banaskantha, Gandhinagar, Mahesana, Patan and Sabarkantha districts was issued from IMD New Delhi.

The district wise five day rainfall forecast of Tuesday for the period from 2015 to 2020 was verified with the observed values of rainfall collected from Gujarat State Disaster Management Authority (GSDMA) website. The critical value of error structure for verification of rainfall were used as per IMD criteria; if the absolute difference is less than or equal to 25% of the observed, the forecast is correct; if the absolute difference lies between 25-50% of the observed, the forecast is usable but not correct; and if the absolute difference is more than 50% of the observed, the forecast is unusable.

To assess the accuracy, success and degree of error of rainfall forecast, different verification methods given by NCMRWF (Singh *et al.*, 1999) were used. Four criteria such as usability, RMSE, HK score and Ratio score were used to test the accuracy of rainfall forecast.

Usability

The correct and usable cases were summed up to indicate percent usability of the forecasts. If the usability percentage is more than 90, the forecast is said to excellent; if it is in between 80-90, forecast is very good; if the values in between 70-80, the forecast considered as good; if usability percentage varied between 60-70, forecast is said to be satisfactory; similarly if it is below 60, forecast is said to be poor. It is calculated as

Usability (%) = Correct cases + Usable cases

Root Mean Square Error (RMSE)

The RMSE value indicates the degree of error in the forecast. The root mean square error (RMSE) was worked out for the absolute error between observed and forecasted values. The lower values of RMSE indicate less difference between observed and forecasted values and vice versa. The RMSE is computed as

$$RMSE = \sqrt{\left\{\frac{1}{n} \sum (F_i - O_i)\right\}}$$

Where, F_i = Forecasted value

O_i = Observed value

n = Number of observations

Hanssen and Kuiper score (HK score)

HK score is the ratio of economic saving over climatology due to the forecast to that of the perfect forecast. The values of HK score vary between -1 and +1. Negative values indicate failure of forecast, Zero value indicates no skill and positive values indicate success of forecast. If the HK score is closer to 1 the forecast is highly successful, if near to 0.5 it is fairly successful. It is calculated as

$$H. K. Score = \frac{YNN - YNNY}{(YY + YN)(NY + NN)}$$

Where,

YY = No of days when rainfall was forecasted and also observed

YN = No of days when rainfall was forecasted but not observed

NY = No of days when rainfall was not forecasted but observed

NN = No of days when rainfall was not forecasted and also not observed

Ratio score

The ratio score varies from 0 to 100 percent. It measures the accuracy of forecast out of total forecasts issued. The ratio score close to zero indicates imperfect forecast and close to hundred indicates perfect forecast. It is calculated by using the formula

$$Ratio Score = \frac{YY + NN}{N} \times 100$$

Results and Discussion

The district wise usability percentage of rainfall forecast from 2015 to 2020 presented in Table 1. The accuracy of rainfall forecast in Banaskantha district was 80.00% and 70.59% in the year 2015 and 2016 respectively which may be considered as good forecast while, the forecast was satisfactory in the year 2017 and 2018. However, the poor accuracy was reported during the year 2019 and 2020 indicated more degree of error between forecasted and observed rainfall. The RMSE value found in between 13.70 to 29.87 over the different years of the study. H.K. score and ratio score varied in between 0.23 to 0.55 and 54.12 to 75.56 respectively during different years which showed the fairly success of forecast. Mean accuracy over the six years period was 64.37% with RMSE, HK score and ratio score of 23.46, 0.41 and 68.27 respectively.

In Gandhinagar district, the highest accuracy (91.53%) was reported during 2015 while, lowest accuracy (49.05%) was reported during 2020. The RMSE value varied in between 14.56 to 24.14 in different years. The performance of forecast was reported excellent in 2015 whereas, good performance was observed in 2016 and 2017.

Table.1 Usability (%) of rainfall forecast for different districts in North Gujarat

Year	Usability (%)	RMSE	H.K.Score	Ratio Score
Banaskantha District				
2015	80.00	22.69	0.38	64.71
2016	70.59	13.70	0.55	75.56
2017	61.20	29.87	0.50	74.44
2018	69.56	21.07	0.23	54.12
2019	55.17	24.72	0.39	66.67
2020	49.68	28.69	0.42	74.12
Mean	64.37	23.46	0.41	68.27
Gandhinagar District				
2015	91.53	16.89	0.33	69.41
2016	72.30	14.56	0.44	72.22
2017	70.67	24.14	0.67	83.33
2018	70.97	17.94	0.46	72.94
2019	57.63	22.37	0.38	67.82
2020	49.05	20.28	0.23	62.35
Mean	68.69	19.36	0.42	71.35
Mahesana District				
2015	82.54	19.15	0.44	74.12
2016	81.16	15.50	0.50	76.67
2017	62.86	23.65	0.55	77.78
2018	77.05	21.08	0.44	71.76
2019	52.29	23.21	0.55	77.01
2020	47.37	20.63	0.34	67.06
Mean	67.21	20.54	0.47	74.07
Patan District				
2015	81.36	20.63	0.32	69.41
2016	80.28	15.49	0.54	78.89
2017	69.70	28.96	0.46	73.33
2018	80.00	25.43	0.23	64.71
2019	57.81	26.40	0.49	73.56
2020	50.88	22.62	0.34	67.06
Mean	70.01	23.26	0.40	71.16
Sabarkantha District				
2015	75.92	19.59	0.26	63.53
2016	66.18	21.72	0.51	75.56
2017	64.29	19.12	0.58	77.78
2018	67.24	25.55	0.45	68.24
2019	55.96	21.24	0.34	67.82
2020	49.02	26.51	0.15	60.00
Mean	63.10	22.29	0.38	68.82

Similarly, HK score and ratio score varied between 0.23 to 0.67 and 62.35 to 83.33 respectively in different year of the study which revealed the fairly success of forecast. However, the forecast was poor during 2019 and 2020. On the basis of overall period of the study, the mean accuracy was 68.69% with RMSE, HK score and ratio score of 19.36, 0.42 and 71.35 respectively.

Similarly, in Mehsana district, the forecast accuracy varied from 47.37 to 82.54% in different years. The performance of forecast was very good during 2015, 2016 and 2018 and satisfactory forecast was found during the year 2017 while, poor accuracy reported in the year 2019 and 2020. The RMSE value found in between 15.50 to 23.65 in different years. H. K. Score varied in between 0.34 to 0.55 over the study period showed fairly success of rainfall forecast. Ratio score ranged 67.06 to 77.78 in different year which also revealed the well accuracy of forecast. Overall basis, the mean accuracy was 67.21% with RMSE, HK score and ratio score of 20.54, 0.47 and 74.07 respectively.

The forecast accuracy of rainfall found good during 2015, 2016, 2017 and 2018 in Patan district. Poor accuracy was reported during the year 2019 and 2020. In different years, the forecast accuracy varied in between 50.88 to 81.36% in the district. The RMSE value found in between 15.49 to 28.96 in different years. Similarly, the H.K. Score and ratio score varied in between 0.23 to 0.54 and 64.71 to 78.89 respectively in different years of the study indicated fairly success of forecast. Overall basis, the mean accuracy was 70.01% with RMSE, HK score and ratio score of 23.26, 0.40 and 71.16 respectively.

In case of Sabarkantha district, the accuracy of forecast was highest (75.92%) during the year 2015. Performance of forecast was also good in the year 2016, 2017 and 2018. The accuracy

was poor during 2019 and 2020 with the value of 55.96% and 49.02% respectively. The RMSE value varied in between 19.12 to 26.51 in all the years. Similarly, HK score and ratio score varied between 0.15 to 0.58 and 60.00 to 77.78 respectively in different year of the study which revealed the fairly success of forecast. On the basis of overall period of the study, the mean accuracy was 63.10% with RMSE, HK score and ratio score of 22.29, 0.38 and 68.82 respectively.

Thus, from the foregoing results, it may be concluded that, the forecast accuracy of rainfall in monsoon season was found good and satisfactory in all the districts during the year 2015, 2016, 2017 and 2018. The forecast accuracy was poor during 2019 and 2020 in all district of the region which is need to be further improvement of medium range weather forecast on rainfall for well application in farming operations. However, the mean basis over the six year period (2015-2020), the forecast was found satisfactory in all the district of the study area. The ratio scores derived between the forecasted and observed values were relatively higher indicating the good performance of forecast. HK scores were also indicated the success of forecast in all the districts during period. Hence, the accuracy of rainfall forecast during monsoon season found to be useful for appropriate field operations and crop management practices in *kharif* crops.

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