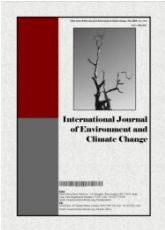

International Journal of Environment and Climate Change

12(11): 2253-2258, 2022; Article no.IJECC.85647
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Rainfall Forecast Verification in Different Blocks of Banka District of Bihar

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2022/v12i1131219

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/85647

Original Research Article

Received 25 April 2022
Accepted 06 June 2022
Published 09 September 2022

ABSTRACT

Accuracy in rainfall forecast plays an important role in farming operations. Here, a study has been done to verify the forecast and actual rainfall data of 11 blocks of Banka district at KVK, Banka. To verify the accuracy of rainfall forecast for the financial year 2020-21 several statistical tools has been used i.e., Forecast Accuracy (ACC) or Ratio Score or Hit Score, Hanssen and Kuipers Scores or True Skill Score (HK score), Probability of detection (POD), Heidke Skill Score (HSS), False alarm ratio, Critical Success index (CSI), Missing Rate (MR) and BIAS score. Forecast Accuracy (ACC) ranged from 0.81 to 0.87 and the highest accuracy of rainfall prediction was observed in Katoriya block and lowest accuracy observed in Amarpur, Dhoraiya and Rajoun block. Similarly, Critical Success Index (CSI) was recorded with the values range of 0.4 to 0.6 for respective blocks of Banka district. Heidke Skill Score (HSS) was accounted as 0.50 for Amarpur, Banka, Barahat, Bounsi, Belhar, Dhoraiya, Rajoun and Shambhuganj and for rest of the blocks it was 0.6. The

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higher accuracy (87.1 per cent) was recorded in Katoriya block followed by Fullidumar (86.3 per cent) and Chandan (85.4 per cent). The highest no. of rainy days was observed in Katoriya block (75 no.) followed by Chandan (74 no.). POD value ranges between 0.8-0.9, FAR value between 0.3-0.5, MR and BIAS value ranges between 0.8-0.9 and 1.3 -2.0 respectively.

Keywords: Rainfall forecast; observed rainfall; rainy day; forecast verification tools.

1. INTRODUCTION

"The aim of the study to verify the forecast values of rainfall during whole year with the recorded values with different types of statistical tools which are presented. This analysis was conducted in KVK, Banka. Medium range weather forecast (provide information five to seven days in advance) and weather based agro-advisories help the farming community by minimizing the losses due to unfavourable conditions. An increase in net return by 4.0 - 5.7% for rice, 2.1 - 4.4% for maize and 3.2 - 4.6% for wheat in different district of Himachal Pradesh due to intervention of weather forecast based agro advisory services (AAS). The AAS farmers have gained 5.26 – 25.00% more income over non AAS farmers from different crops" [1]. "So, there is a need to study reliability and suitability of the medium range weather forecasts. So, there is need to study reliability and suitability of the different types of weather forecasts for further improvement. Agriculture in India mainly depends on weather and climatic conditions. Weather condition plays a great role for modifying agricultural production. For effective planning and management of agricultural practices such as selection of cultivar, sowing, need-based application of fertilizer, pesticides and efficient irrigation as well as harvesting. Medium range weather forecast greatly contribute towards making short-term adjustments in daily agricultural operations which minimize losses resulting from adverse weather conditions and improve yield and quantity as well as quality of agricultural productions" [2]. "A great portion of loss in agricultural sector was contributed by aberrant weather condition. In this regard timely weather information allows farmers to plan their farm operations in a way that helps in exploiting the yield levels as well as reduction in crop loss. Forecast verification is very important to find its accuracy by comparing the forecast data with the observed rainfall data either qualitatively and quantitatively. In either case, it is necessary to provide information on the nature of forecasting errors, due to their strengths or weaknesses of a forecasting system. Verification of precipitation is very important as it is one of the important end products with a more practical application for the user community" [3]. "Since these are very discontinuous parameters and the representativeness of the ground truth on which to carry out the verification depends mainly on the quality, density and pre-processing of the observed data. A weather element may be either a continuous or a categorical variable. Parameters like rainfall take discrete values like 0 (no rain) and 1 (rain) and hence is a categorical variable" [3]. "The agromet advisory bulletin is prepared for the next five days for the district and different blocks of respective district based on crop and weather forecast information received from the field visit, whatsapp group and IMD website. The weather parameters forecasted are maximum temperature, minimum temperature, relative humidity of morning and afternoon, cloud cover, rainfall and wind speed and direction. The bulletin contains advisories pertaining to selection of variety, sowing time, input management, in situ moisture conservation, plant protection measures and contingency plans on need basis. Verification scores used as performance indicators and targets can encourage action to improve forecasting" [3].

2. MATERIALS AND METHODS

Gramin Krishi Mausam Sewa (Agromet advisory service) is being implemented at KVK, Banka since 2018. From IMD the weather forecast for 11 blocks of Banka district is received on every day and district level value added forecast is received on every Tuesday and Friday for the next five days from Regional Meteorological Centre, Patna. But here we analysed the block level rainfall forecast with rainfall data received from DAO, Banka. The standard approach is to record the frequencies with which the event was observed and forecasted in a two by- two tables, and then to quantify forecast quality with summary measures of the table. The frequency with which rare events are observed may be low, which increases sampling variation in such measures and creates uncertainty about forecast quality [4].

2.1 Qualitative Verification of Rainfall Forecast

It gives information about the skill of the forecast as well as the type of errors that occur in the forecast. Qualitative verification is done with the help of following scores

Forecast / Observation	Rain	No Rain
Rain	A (YY)	B (YN)
No Rain	C (NY)	D (NN)

A = No. of Hits (predicted and observed)
B = No. of False Alarms (predicted but not observed)
C = No. of misses (observed but not predicted)
D = No. of correct predictions of no rain (neither predicted nor observed)

2.2 Forecast Accuracy (ACC) or Ratio Score or Hit Score

It is the ratio of correct forecasts to the total number of forecasts.

$$\mathrm{ACC} = \frac{\text{Correct Forecast}}{\text{Total Forecast}} = \frac{\mathrm{A} + \mathrm{D}}{\mathrm{N}} = \frac{\mathrm{YY} + \mathrm{NN}}{(\mathrm{YY} + \mathrm{NN} + \mathrm{YN} + \mathrm{NY})}$$

2.3 Hanssen and Kuipers Scores or True Skill Score (HK score)

It is the ratio of economic saving over climatology due to the forecast to that of a set of perfect forecasts. If all forecast are perfect then it is +1 and if all forecast are wrong then it is – 1.

$$\mathrm{HK} = \frac{\text{Correct Forecast} - (\text{Correct Forecast})\text{random}}{\mathrm{N} - (\text{Correct Forecast})\text{random, unbiased}}$$

$$HK = (Acc)\,events + (Acc)\,non-events - 1 = \frac{AD - BC}{(A + C)(B + D)} - 1$$

2.4 Probability of Detection (POD)

$$\mathrm{POD} = \frac{\text{Correct rain forecast}}{\text{Rain observation}} = \frac{\mathrm{A}}{\mathrm{A} + \mathrm{C}}$$

Range: 0 to 1; Perfect Score 1

2.5 Heidke Skill Score (HSS)

It accounts for all correct forecast (events and non- events) that would be made due to chance. It varies from -α to 1 with 0 indicating no skill compared with random or chance forecast and 1 indicating perfect forecast.

$$\mathrm{HSS} = \frac{\text{Correct Forecast} - (\text{Correct Forecasts})\text{ random}}{\mathrm{N} - (\text{Correct Forecasts})\text{ random}}$$

$$\mathrm{HSS} = \frac{2(\mathrm{AD} - \mathrm{BC})}{(\mathrm{A} + \mathrm{C})(\mathrm{C} + \mathrm{D}) + (\mathrm{A} + \mathrm{B})(\mathrm{B} + \mathrm{D})}$$

2.6 False Alarm Ratio (FAR)

$$\mathrm{FAR} = \frac{\text{False alarms}}{\text{Hits} + \text{False alarms}} + \frac{\mathrm{B}}{\mathrm{A} + \mathrm{B}}$$

2.7 Critical Success Index or Threat Score (CSI)

"It is a measure of relative forecasting accuracy (e.g. rain or no rain). It varies from 0 to 1 with 1 indicating perfect forecast and is defined as the ratio of the number of hits (Correct event forecast) to the number of events which occurred plus the number or false alarms (incorrect event forecasts)" [5].

$$CSI = \frac{Hits}{Hits + False\ alarms} = \frac{A}{A + B + C} = \frac{Correct\ Rain\ Forecast}{Rain\ Forecast + Observations}$$

2.8 Missing Rate (MR)

$$MR = \frac{Misses}{Misses + False\ alarms} + \frac{B}{B + C}$$

2.9 BIAS Score BIAS

$$\mathrm{MR} = \frac{\text{Rain forecast}}{\text{Rain Observation}} = \frac{\mathrm{A} + \mathrm{B}}{\mathrm{A} + \mathrm{C}}$$

3. RESULTS AND DISCUSSION

The district received an annual rainfall of 1189.7 mm with monsoonal rainfall 877.6 mm during the year 2020. The forecast thus verified with the actual weather data by adopting the standard method of forecast verification and the results are presented below.

The analysis of rainfall verification for the year April 2020- March 2021 revealed that, the number of hits (predicted and observed as no rain - NN) was 243.0, 250.0, 248.0, 245.0, 245.0, 242.0, 246.0, 244.0, 238.0, 245.0 & 252.0, the occurrences of rain (YY) were 55.0, 57.0, 58.0,

58.0, 61.0, 70.0, 52.0, 71.0, 80.0, 52.0 & 54.0, the numbers of false alarms (predicted but not observed (YN) were 59.0, 51.0, 51.0, 53.0, 52.0, 45.0, 58.0, 43.0, 39.0, 63.0 & 55.0 and the number of misses (not predicted but observed (NY) were 8.0, 7.0, 8.0, 9.0, 7.0, 8.0, 9.0, 7.0, 8.0, 5.0 & 4.0 over 365 forecasts for Amarpur, Banka, Barahat, Bounsi, Belhar, Chandan, Dhoraiya, Fullidumar, Karoriya, Rajoun and Shambhuganj blocks of Banka district, respectively as mentioned in Table.1 and the graphical representation of these values are shown in Fig.1.

Critical Success Index or Threat Score (CSI) is a measure of relative forecasting accuracy (e.g. rain or no rain). It varies from 0 to 1 with 1 indicating perfect forecast and it is the ratio of the number of hits (correct event forecast) to the number of events which occurred plus the number or false alarms (Incorrect event forecasts). Critical Success Index or the Threat Score (CSI) was ranged from of 0.4 to 0.6 for respective blocks of Banka district. The HK scores of 0.6-0.7 was recorded for all blocks which denote the forecast for rainfall is almost perfect during the year 2020-21. Forecast Accuracy (ACC) ranged from 0.81 to 0.87 and the highest accuracy of rainfall prediction was observed in Katoriya block and lowest accuracy observed in Amarpur, Dhoraiya and Rajoun block. Similarly, Critical Success Index (CSI) was recorded with the values range of 0.4 to 0.6 for respective blocks of Banka district. Heidke Skill Score (HSS) was accounted as 0.50 for Amarpur, Banka, Barahat, Bounsi, Belhar, Dhoraiya, Rajoun and Shambhuganj and for rest of the blocks it was 0.6.

The higher accuracy (87.1 percent) was recorded in Katoriya block followed by Fullidumar (86.3 percent) and Chandan (85.4 percent). The highest no. of rainy days was observed in Katoriya block (75 no.) followed by Chandan (74 no.). POD value ranges between 0.8-0.9, FAR value between 0.3-0.5, MR and BIAS value ranges between 0.8-0.9 and 1.3 -2.0 respectively as Table.2.

Accurate forecasting helps the farming communities to take right decision at right time likes scheduling irrigation and spraying time, fertilizer application, harvesting etc. The blocks having highest no. of rainy day received more rain water that helps the farmers of that blocks during rabi season because there is no rainfall occurred in Banka district after monsoon withdrawal to mid-April.

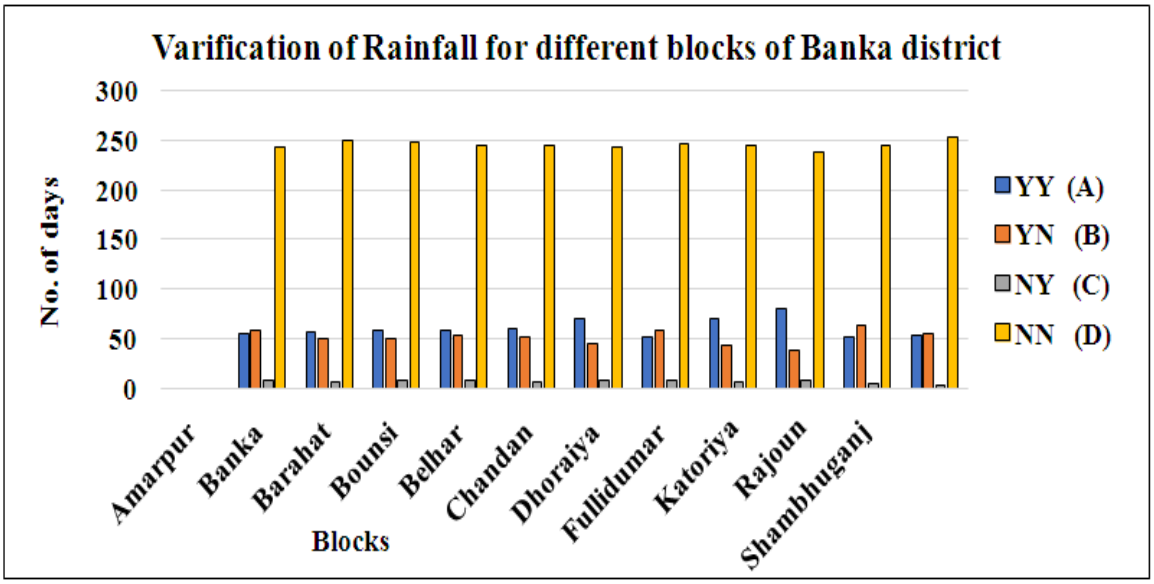

Fig. 1. Verification of Rainfall forecast and Ratio Score for different blocks of Banka district of Bihar (April 2020- March 2021)

Table 1. Verification of Rainfall forecast for different blocks of Banka district of Bihar (April 2020- March 2021)

Blocks	Total no. of days	Successful forecasting (days)	Forecast failure (days)	Accuracy (%)	YY (days)	YN (days)	NY (days)	NN (days)	Total observed rainy days (rf>2.5mm)
Amarpur	365	298	67	81.6	55	59	8	243	53
Banka	365	307	58	84.1	57	51	7	250	54
Barahat	365	306	59	83.8	58	51	8	248	49
Bounsi	365	303	62	83.0	58	53	9	245	61
Belhar	365	306	59	83.8	61	52	7	245	45
Chandan	365	312	53	85.4	70	45	8	242	74
Dhoraiya	365	298	67	81.6	52	58	9	246	47
Fullidumar	365	315	50	86.3	71	43	7	244	67
Katoriya	365	318	47	87.1	80	39	8	238	75
Rajoun	365	297	68	81.3	52	63	5	245	58
Shambhuganj	365	306	59	83.8	54	55	4	252	52

Table 2. Ratio score and the values of different statistical tools/methods for rainfall verification in different blocks of Banka district of Bihar (April 2020- March 2021)

Blocks	ACC	HK	POD	HSS	FAR	CSI	MR	BIAS
Amarpur	0.81	0.67	0.87	0.51	0.51	0.45	0.88	1.80
Banka	0.84	0.72	0.89	0.56	0.47	0.49	0.87	1.68
Barahat	0.83	0.71	0.87	0.56	0.46	0.49	0.86	1.65
Bounsi	0.83	0.69	0.86	0.54	0.47	0.48	0.85	1.65
Belhar	0.83	0.72	0.89	0.57	0.46	0.50	0.88	1.66
Chandan	0.85	0.74	0.89	0.63	0.39	0.56	0.84	1.47
Dhoraiya	0.81	0.66	0.85	0.50	0.52	0.43	0.86	1.80
Fullidumar	0.86	0.76	0.91	0.65	0.37	0.58	0.86	1.46
Katoriya	0.87	0.77	0.90	0.68	0.32	0.62	0.82	1.35
Rajoun	0.81	0.71	0.91	0.50	0.54	0.43	0.92	2.01
Shambhuganj	0.83	0.75	0.93	0.55	0.50	0.47	0.93	1.87

4. CONCLUSION

The results showed that, the prediction for rainfall has been found to be quite accurate for whole financial year and need to be improvement in usability of rainfall because rainfall is an important parameter to make decision on the crop production. BAIS value more than one indicated that the forecast system has a tendency to over forecast (BIAS>1) or under forecast (BIAS<1) events. The value does not measure how well the forecast corresponds to the observations, only measures relative frequencies. Highest number of rainy days was observed in Katoriya block (75) followed by Chandan block (74). The positive HKS indicated the reliability of forecast to be satisfactory level. Improvement in forecast accuracy and by reducing the no. of false alarms and the no. of misses will definitely provide more benefits to the farming community.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/85647