RESEARCH PAPER:

Validity testing of weather forecast received from IMD with real time data at ZARS. Sub-montane Zone, Kolhapur (M.S.)

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SUMMARY

The Zonal Agricultural Research Station at Kolhapur is recently sanctioned centre of the IAASU network from NCMRWF in 2005-06. The validity of weather forecast received from NCMRWF for monsoon and post-monsoon season was tested separately with real time data observed from station observatory. The ratio scores on Yes/No basis *viz.,* Forecast Accuracy (ACC), Critical Success Index (CSI), Heidke Skill score (HSS), Hansen and Kuiper's (HK) scores were used for testing of only rainfall prediction. The predicted rainfall on Yes/No basis for both monsoon and post-monsoon periods was 84 per cent correct, whereas it was 81.2 per cent correct for post-monsoon and 71.3 per cent correct for monsoon period. The weather forecast for other parameters was tested with Critical Values for Error Structure as suggested by NCMRWF. On annual basis, the prediction of wind speed (29.4 %), wind direction (12.0 %) and Tmin (51.7 %) were having maximum correct events, whereas the predicted Tmax (26.1 %) and Cum. rainfall (48.7 %) were having maximum number of failure events. On seasonal basis, the predictions for Tmin (62.2 %), wind speed (47.0 %) and wind direction (8.7%) during monsoon period and wind speed (11.8%), cum. Rainfall (73.9%) and Tmax (42.4%) during post monsoon period were having higher percentage of correct events. However, the cum. rainfall (84.4%) and Tmax. (29.6%) during monsoon and wind direction (84.7 %) and Tmin. (32.9 %) during post monsoon period were having maximum number of failure events. The values of coefficient of determination $r^2 = 0.96$ in the regression analysis during post monsoon period indicated better accuracy in prediction of minimum temperature Likewise the rainfall event on July 26, 2005 was the most historical event in the Kolhapur since year 1975. The rainfall recorded on this event was 207.0 mm as against the predicted rainfall from NCMRWF was only to the extent of 25.0 mm. Such types of events at least need most accurate predictions in advances. It is therefore felt that the model needs modification in view of flood control measures and agricultural production.

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The Integrated Agro-Advisory Services Unit (IAASU) is the sponsored scheme by the India Meteorological Department, Ministry of Earth and Science, New Delhi. It is functioning at Zonal Agricultural Research Station at Kolhapur since November 2005-06. ZARS at Kolhapur is the major centre functioning for Sub-montane zone of Maharashtra with leading stations at Karad, Gadhinglaj and Vadagaon Maval in its jurisdiction. The zone consists of 24 Tahasils of 8 districts in Western Maharashtra. The name of zone itself indicates it as a transition stage between Western Ghat and Western Maharashtra Plain Zones.

The four-day weather forecast is received through fax from the IMD on every Tuesday and Friday. It consists of eight weather parameters *viz.,* rainfall (daily and cumulative), wind speed (kmph), wind direction (degrees), change in maximum and minimum temperatures, relative humidity morning and afternoon (%). The group of scientists from various disciplines discuss the weather of last week, forecasted weather and the present stage of crop or crop condition. On the basis, the package of practices to be adopted by the farmers following advance knowledge of weather is broadcasted in the form of Agro-Advisory Bulletin through All India Radio, Kolhapur. The advance knowledge of weather and the action plan suggested is important for the farmers for their farm planning. However,

its success, depends on the reliability of weather forecast issued by the IMD. The present study deals with the validity testing of weather forecast received from IMD with real time data observed from the station observatory.

MATERIALS AND METHODS

The weather forecast consisting of eight parameters *viz.,* cloud cover (octa), rainfall (daily and cumulative), wind speed (km/h), wind direction (degrees), change in maximum and minimum temperatures for monsoon (June to September) and post monsoon (October to December) period was verified with the observed data from the station observatory. The methods adopted for verification are given as below:

Discrete variable:

The rainfall is a categorical or discrete variable, verified by using the contingency table approach (Murphy and Winkler, 1987; Murphy *et al.,* 1989; Schafer 1990). It gives information about the skill of forecast as well as types of errors that occurs in the forecast.

The ratio score (Y/N basis), Critical Success Index (CSI), Heidke Skill Score (HSC) and Hansen and Kuipers Score (HKS) are adopted for verification of predicted rainfall.

$$\text{Forecast accuracy (ACC)} = \frac{YY + NN}{YY + NN + NY + YN}$$

$$\text{Critical Success Index (CSI)} = \frac{YY}{YY + NY + YN}$$

$$\text{Heidke Skill Score (HSS)} = \frac{(NN \times YY) - (NY \times YN)}{[(NN + YN)(YN + YY) + (NN + NY)(NY + YY)]/2}$$

$$\text{Heidke Skill Score (HSS)} = \frac{(NN \times YY) - (NY \times YN)}{[(NN + NY)(YN + YY))]}$$

where,

YY-Predicted and observed rainfall

YN-Predicted but not observed rainfall

NY-Not predicted but observed rainfall

NN-Neither predicted nor observed

Critical value for error structure:

The weather parameter *viz.,* Tmax, Tmin, wind speed, wind direction and cumulative rainfall forecasted from NCMREF were analysed by using Critical Value Error Structure as given below:

Critical values for error structure as suggested by NCMRWF				
Parameter	Cum. rainfall	Temperature	Wind speed	Wind direction
Correct (C)	- 10 to + 10 mm variation	1 ^{0}C variation	3	– 45^0 to + 45^0 variation
Usable (U)	- 20 to + 20 mm variation	2 ^{0}C variation	6	– 60^0 to +60^0 variation
Failure (F)	Otherwise	Otherwise	Otherwise	Otherwise

Regression analysis :

The regression analysis between was carried out between observed as a dependent variable (Y) and predicted weather parameters as an independent variable (X). The coefficients of correlation (r), coefficient of determination (r^2), root mean square error (RMSE) were worked out for each weather parameters.

RESULTS AND DISCUSSION

The findings obtained from the present study are presented below:

Analysis of rainfall forecast:

The data of actual and forecasted rainfall were analyzed separately for pre-monsoon, monsoon, post-monsoon and winter period during year 2008 (Table 1).

Forecast accuracy (ACC) or ratio score:

ACC is the ratio of correct forecast to total number of forecast for rainfall events. It is worked out on Yes/ No basis for pre monsoon, monsoon, post monsoon and winter season. It was highest (98.9 per cent) for winter season and lowest (71.3 per cent) for monsoon season, whereas it was 84 per cent for overall period.

Critical success index (CSI) or threat score:

It is the relative measure of forecast accuracy (rain or no rain). It varies from 0 to 1. The value 1 indicates perfect forecast. It is the ratio of number of hits (correct events) to number of events that occurred plus number of false events (incorrect events). The CSI values for winter and pre-monsoon period were 0.99 and 0.9, respectively. It was 0.78 for whole year (Table 1).

Heidke skill score (HSS) :

It considers all correct forecast events (events and non-events) that would make due to chance. It varies from –1 to +1 with 0 indicating no skill compared with chance forecast. The HSS for post-monsoon and pre-

monsoon period were 0.47 and 0.24, respectively. It was 0.64 for whole year (Table 1).

Hansen and Kuiper's Score or True Skill Score (HK Score):

The HK Score is the ratio of economic saving over climatology due to the forecast to that of a set of perfect forecasts. It ranges from –1 to + 1 with 0 indicating no skill. The HK scores for winter and pre-monsoon period were -0.01 and 0.21, respectively. It was 0.74 for whole year (Table 1).

Annual analysis :

The predicted and observed weather parameters were analyzed for Correct (C), Usable (U) and Failure (F) events in terms of percentage (Table 2). The highest percentages of correct events were 61.5 % for cumulative rainfall and 58.6 % for rainfall. However, the highest percentages of 51.6 % failure events was observed for wind speed.

Seasonal analysis:

The analysis presented in (Table 3) shows the seasonal distribution (%) of 'Correct', 'Usable', and 'Failure' events of predicted weather parameters. The highest percentages *i.e.* 88.7 % of correct events was observed for rainfall and 87.5% for cumulative rainfall during pre-monsoon period.

During monsoon period, the highest percentage *i.e.* 65.2% of correct events was observed for Tmin, 47% for wind speed and 38.3% for Tmax, whereas 93% failure events were observed for rainfall.

In post monsoon season, the highest percentage 73.9% of correct events was observed for cumulative rainfall. Similarly, highest percentage of failure events was observed for relative humidity II (90.6%)

During winter season cent per cent correct events were observed for cumulative rainfall and 98.9% for rainfall.

Table 1: Forecast verification of rainfall at Kolhapur during 2008

Season	Total	YY	YN	NY	NN	ACC Score (%)	CSI	HSS	H. K. Disc.
Pre-monsoon (April-May)	53	47	2	3	1	90.6	0.9	0.24	0.21
Monsoon (June-Sept.)	115	2	32	1	80	71.3	0.06	0.06	0.05
Post-monsoon (Oct.-Dec.)	85	59	15	1	10	81.2	0.79	0.47	0.71
Winter (Jan.-Feb.)	90	89	0	1	0	98.9	0.99	-0.02	-0.01
Total	343	197	49	6	91	84.0	0.78	0.64	0.74

Table 2: Annual distribution (%) of 'Correct', 'Usable', and 'Failure' of predicted weather parameters at Kolhapur (Year 2008)

Rating of predicted data	Tmax	Tmin	Rain	TCC	RH I	RH II	Wind speed	Wind direction	Cumulative rainfall
Correct(C)	39.4	47.8	58.6	44.0	11.3	7.4	28.3	13.0	61.5
Usable (U)	33.8	26.8	2.3	14.9	0.0	1.8	20.1	40.9	5.2
Failure (F)	26.8	25.4	39.1	41.1	88.7	90.8	51.6	46.1	33.3

Table 3: Seasonal distribution (%) of 'Correct', 'Usable' and 'Failure' of predicted weather parameters at Kolhapur (Year 2008)

Season	Rating of predi. data	Tmax.	Tmin.	Rain	TCC	RH I	RH II	W.S.	W.D.	Com.RF
Pre-monsoon	(C)	43.4	49.1	88.7	37.7	-	-	43.4	5.7	87.5
(April-May)	(U)	41.5	32.1	1.9	41.5	-	-	26.4	0.0	0.0
	(F)	15.1	18.9	9.4	20.8	-	-	30.2	94.3	12.5
Monsoon	(C)	38.3	65.2	4.3	4.3	19.3	9.2	47.0	8.7	9.4
(June-Sept.)	(U)	29.6	19.1	2.6	6.1	0.0	0.9	23.5	0.0	6.3
	(F)	32.2	15.7	93.0	89.6	80.7	89.9	29.6	91.3	84.4
Post-monsoon	(C)	42.4	41.2	70.6	50.6	12.9	8.2	11.8	15.3	73.9
(Oct - Dec)	(U)	37.6	25.9	4.7	18.8	0.0	1.2	12.9	0.0	13.0
	(F)	20.0	32.9	24.7	30.6	87.1	90.6	75.3	84.7	13.0
Winter	(C)	35.6	31.1	98.9	92.2	0.0	4.4	11.1	11.1	100
(Jan-March)	(U)	31.1	34.4	0.0	6.7	0.0	3.3	18.9	0.0	0.0
	(F)	33.3	34.4	1.1	1.1	100	92.2	70.0	88.9	0.0

Correlation coefficient (r):

Regression analysis:

The values of coefficient of determination were worked out for regression analysis between observed and predicted weather parameters (Table 4). The values of predicted rainfall are not matching with the observed ones. It means that prediction of rainfall is most inaccurate. The highest value (0.96) of coefficient of determination (r^2) during post monsoon period indicates better accuracy in prediction of minimum temperature.

Table 4: The RMSE, per cent error and correlation coefficients of observed and predicted weather parameters at Kolhapur (Year 2008)

Sr. No.	Parameters	RMSE	Per cent error	Correlation coefficient
1.	Tmax.	02.5	08.0	0.79
2.	Tmin.	02.0	10.2	0.73
3.	RH I	39.3	51.0	0.67
4.	RH II	30.5	53.2	0.4
5.	Wind speed	03.0	64.4	0.4
6.	Wind direction	81.9	44.3	0.6
7.	Rainfall	20.9	515.8	0.34
8.	Total cloud cover	03.5	412.8	0.7
9.	Weekly rainfall	23.87	124.3	0.77

Conclusion:

The rainfall is the most important weather parameter in agricultural production and management practices. In view of this, the rainfall prediction should be most accurate for planning farm operations. However, the minimum values of coefficient of determination r^2 indicates the most inaccurate prediction of rainfall. The prediction of rainfall in qualitative terms on Yes/No basis is 78% accurate for the whole year. However, it failed to get accurate predictions in quantitative terms. It is therefore felt that the model needs modification in view accurate rainfall prediction to support agricultural production and flood management.

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