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ML Sahu
Department of India Meteorological, Regional Meteorological Centre, Nagpur, Maharashtra, India

Latha Sridhar
Department of India Meteorological, Regional Meteorological Centre, Nagpur, Maharashtra, India

Albert N Minz
Department of India Meteorological, Regional Meteorological Centre, Nagpur, Maharashtra, India

Sulekha Sonal
Department of India Meteorological, Regional Meteorological Centre, Nagpur, Maharashtra, India

Corresponding Author:
ML Sahu
Department of India Meteorological, Regional Meteorological Centre, Nagpur, Maharashtra, India

Model and value added forecast verification analysis for rainfall and temperature for districts of Vidarbha

ML Sahu, Latha Sridhar, Albert N Minz and Sulekha Sonal

Abstract
For the benefit of farming community during various crop stages, district-wise Medium range weather forecast for the subsequent 5 days is disseminated to the DAMU (District Agromet advisory unit) and KVK (Krishi Vigyaan Kendra) every Tuesday and Friday for all the districts of Vidarbha by Regional Meteorological Centre, Nagpur. In this study, the verification of medium range weather forecasts (both GFS-T1534 model and value added) for districts of Vidarbha for the four seasons during the period 2021-2022 (SW Monsoon season 2021 to pre-monsoon season 2022) are discussed for temperature and rainfall. Rainfall forecast for almost all the districts revealed higher accuracy during post-monsoon to pre-monsoon and little less accuracy during the SW Monsoon season. However, the accuracy of value-added forecasts was higher than those of the model forecasts in all the seasons. The maximum and minimum temperature forecasts revealed higher accuracy during all the seasons for most of the districts for value added forecasts as compared to the model forecasts.

Keywords: Vidarbha, weather forecast, verification, rainfall, temperature

1. Introduction
India is an agrarian country and agricultural output is mainly dependent on weather and climatic conditions. Timely advice to the farmers about the weather conditions help them plan their sowing and take appropriate precautions during adverse weather conditions to save their crops from damages and minimize losses. As an important step to reach to the farming community at various districts across the country, IMD started issuing quantitative district level weather forecast upto 5 days from 1st June, 2008 [1, 2] for the preparation and dissemination of District Level Agromet Advisory Bulletins. The IMD GFS-T1534 model generates forecasts for weather parameters for the districts across India for various weather parameters, *viz*. maximum and minimum temperatures, rainfall, relative humidity, wind speed and direction and cloud cover. Based on the model outputs, prevalent synoptic conditions over the region and its neighbourhood, climatology of the region, products obtained from various other models, products obtained by Doppler Weather Radars and satellite imageries during the forecast day, suitable value additions are done for all these weather parameters for the subsequent 5 days. This information after value addition is further disseminated to the farmers by DAMU and KVK of the district on the various agronomic practices to be followed to increase crop production and to minimize the production losses in case of adverse weather conditions.
Vidarbha, a meteorological subdivision of India is in the eastern region of Maharashtra state and comprises of 11 districts, namely, Akola, Amravati, Bhandara, Buldhana, Chandrapur, Gadhchiroli, Gondia, Nagpur, Wardha, Washim and Yeotmal (Figure-1). Vidarbha region of Maharashtra state is not as much economically prosperous as compared to the rest of the state. The economy of Vidarbha is largely dependent on agriculture. Medium range model based weather forecasts contribute largely in day-to-day agricultural operations and crop yield [3, 4].
However, value additions to these model based forecasts are effective towards planning the appropriate adjustments in daily agricultural practices in localized areas to improve both qualitative and quantitative agricultural productions. To improvise upon the quality of agromet advisories disseminated, it is necessary to verify the forecasts issued. [5] have studied the model based forecasts efficacy for rainfall for the entire country excluding Vidarbha region of Maharashtra. Not many studies in this regard have been done for Vidarbha region.
Hence in the present study, an attempt has been made to verify the 5-day forecasts for rainfall and temperature over the districts of Vidarbha and to compare the value added forecasts with the model based forecasts.

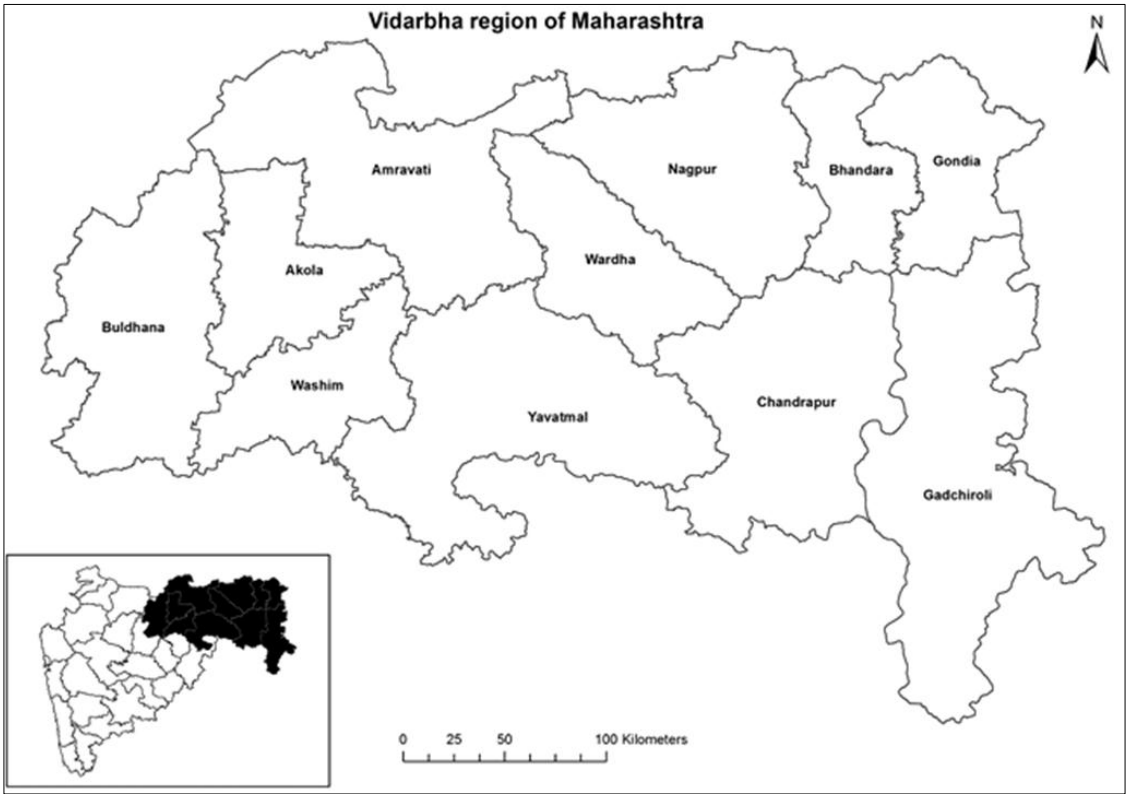

Fig 1: Vidarbha Region of Maharashtra

2. Materials and method

The values of rainfall and temperature as obtained by 5 day GFS-T1534 model forecast data output of every Tuesdays and Fridays, 5 day Value added forecast data output of every Tuesdays and Fridays, Observed Rainfall and Temperature (Maximum & Minimum) data over the study region for the study period for the districts of Vidarbha have been used for verification. The daily temperature and rainfall of the district has been computed by calculating the simple arithmetic average of the values obtained by the departmental and part-time observatories within the district. Forecast accuracy is a measure of how close it was to the weather that actually occurred. In this study, the number of days in the season when the forecast was close to the observed weather has been considered as the accuracy of the forecast (correct, usable and incorrect) on the basis of error structure as discussed by [5].

For rainfall

(A) The error Structure for verification of rainfall forecast:
Correct Diff ≤ 25% of observed
Usable 25% of observed < Diff ≤ 50% of observed
Unusable Diff > 50% of observed
(Diff is the absolute difference between observed and forecast rainfall)

Besides, various skill scores like (WMO Technical Circular No.- WMO/TO No.1023 Guidelines on Performance Assessment of Public Weather Services) have also been used to verify the forecast using the following formulae based on the matrix (2 × 2) given below:

Observed/Forecasted	Rainfall	No Rainfall
Rainfall	A	B
No Rainfall	C	D

While,
N = Total no. of forecast days
= Total no. of days – no. of missing days

A = No. of days when rain was forecasted and also observed
B = No. of days when rain was forecasted but not observed
C = No. of days when rain was not forecasted but observed
D = No. of days when rain was not observed and also not forecasted
MAT = No. of matching cases (A + D)
RS = Skill Score or Ratio Score of rainfall

$$= \frac{MAT}{N} * 100$$

HKS = Hanssen & Kuipers Score

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

Range: -1 to +1
Perfect: 1
Advantage: equal emphasis to yes/no events

$$POD = \text{Percentage of detection} = \frac{A}{(A+C)}$$

Range: 0 to 1
Perfect Score: 1

$$FAR = \text{False alarm ratio} = \frac{B}{(A+B)}$$

$$CSI = \text{Critical Success index} = \frac{A}{(A+B+C)}$$

HSS = Heidke Skill Score

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

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(f_i - o_i)^2}$$

Where
fi = value forecasted
oi = value observed
Σn = total observations

For maximum & minimum temperatures

(B) The error structure considered for verification of temperature forecast:

Correct Diff ≤ 1 °C
Usable 1 °C < Diff ≤ 2 °C
Unusable Diff > 2 °C
(Diff is the absolute difference between observed and forecast temperatures)

3. Results and discussion

The value addition forecasts and model based forecasts are generated for Rainfall and temperatures (Maximum & Minimum) for all the 11 districts of Vidarbha. Since Bhandara district doesn't yet have any departmental (IMDs) full time or part-time observatory, the verification analysis for these meteorological parameters could not be carried out for Bhandara. For the rest of the districts, the verification analysis and comparison between model based and value added forecasts have been carried out. The graphs for both Rainfall anf temperature show the qualitative efficacy of the model based and value added forecasts in terms of Correct+ Usability and Incorrect expressed in percentage. The first (second) bar in the figures (bar graphs) for each day indicates Model based (value added) forecast efficacy (Correct+ Usability). Similarly, the third (fourth) bar in the figures (bar graphs) for each day indicates Model based (value added) forecast inefficacy (Incorrect).

3.1 Verification Analysis for Rainfall

3.1.1 Verification of Rainfall for Akola

As seen from Table-1 and Figure-2, the qualitative forecast for rainfall during the SW monsoon season of the study period was <60% for the model based forecasts, the value added forecast was observed to be >=60% for Days 3, 4 and 5. However, the qualitative efficacy of model based forecast was marginally better than that of the value added forecast for day 1. For Day 2, the qualitative forecast of model based was <40% while that of the value addition was about 50%. From Table-1, it can also be seen that the skill scores for all the 5 days were better for value added forecasts as compared with those of the model forecasts for SW Monsoon 2021. RMSE for all the 5 days w.r.t. value added forecast was much less than those of the model based forecasts, which shows that the value added forecasts were qualitatively better as compared to the model based forecasts. As seen from Table-1 and Figure-2, qualitative forecast for rainfall during the Post Monsoon season of 2021 were >80% for both model based and value added forecasts with value added forecast slightly better for all the 5 forecasted days. From Table-1, it can also be seen that the skill scores and RMSE for all the 5 days were better for value added forecasts for the Post Monsoon Season of 2021. As seen from Table-1 and Figure-2, qualitative forecast for rainfall during the winter season of 2022 were >80% for both model based and value added forecasts in terms of correct and usable forecasts. However, the qualitative efficacy of the value added forecast was better than the model based forecasts for the first 3 forecasted days. For the days 4 & 5, the model based forecasts as well as the value added forecasts were qualitatively almost the equal. From Table-1, it can be seen that the RS and HKS scores were better for model based forecasts for Days 1, 2 & 4. RMSE for all the 5 days w.r.t. value added forecast was marginally lower than those of the model based forecasts. During winter season the model based forecasts were qualitatively very effective and the value additions did not make any large difference. The value added forecasts during Pre Monsoon Season 2022 did not make any large difference to the model based forecasts. As seen from Table-1 and Figure-2, the model based forecasts and the value added forecasts were qualitatively almost at par. RMSE for all the 5 days w.r.t. value added forecast was however marginally lower than those of the model based forecasts during this season.

Table 1: Verification of Forecasted rainfall (Model & Value added) for Akola

AKOLA	MONSOON 2021										AKOLA	POST MONSOON 2021									
	Model Forecast					Value Added Forecast						Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5		Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	34	34	34	34	34	34	34	34	34	34	N	27	27	27	27	27	27	27	27	27	27
A	29	25	24	26	26	30	28	26	29	29	A	1	2	1	2	2	2	3	2	2	2
B	3	4	8	4	4	1	4	5	4	3	B	5	2	6	4	7	5	3	6	5	6
C	1	3	2	3	3	1	2	3	1	2	C	2	1	1	1	0	1	0	0	1	0
D	1	2	0	1	1	0	0	0	0	0	D	19	22	19	20	18	19	21	19	19	19
MAT	30	27	24	27	27	30	28	26	29	29	MAT	20	24	20	22	20	21	24	21	21	21
RS	88.2	79.4	70.6	79.4	79.4	88	82.4	76.5	85.3	85.3	RS	74.1	88.9	74.1	81.5	74.1	77.8	88.9	77.8	77.8	77.8
HKS	0.2	0.2	-0.1	0.1	0.1	0.0	-0.1	-0.1	0.0	-0.1	HKS	0.1	0.6	0.3	0.5	0.7	0.5	0.9	0.8	0.5	0.8
POD	1.0	0.9	0.9	0.9	0.9	1.0	0.9	0.9	1.0	0.9	POD	0.3	0.7	0.5	0.7	1.0	0.7	1.0	1.0	0.7	1.0
FAR	0.1	0.1	0.3	0.1	0.1	0.0	0.1	0.2	0.1	0.1	FAR	0.8	0.5	0.9	0.7	0.8	0.7	0.5	0.8	0.7	0.8
CSI	0.9	0.8	0.7	0.8	0.8	0.9	0.8	0.8	0.9	0.9	CSI	0.1	0.4	0.1	0.3	0.2	0.3	0.5	0.3	0.3	0.3
HSS	0.3	0.2	-0.1	0.1	0.1	0.0	-0.1	-0.1	0.0	-0.1	HSS	0.1	0.5	0.1	0.3	0.3	0.3	0.6	0.3	0.3	0.3
RMSE	26.2	26.0	14.0	13.3	18.5	11.5	10.4	14.6	8.4	9.9	RMSE	14.9	11.9	18.5	17.1	20.5	5.7	1.7	2.7	6.0	4.6
AKOLA	WINTER 2022										AKOLA	PRE MONSOON 2022									
	Model Forecast					Value Added Forecast						Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5		Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	16	16	16	16	16	16	16	16	16	16	N	27	27	27	27	27	27	27	27	27	27
A	1	1	1	1	0	1	0	1	1	2	A	1	1	0	1	1	2	1	0	1	1
B	1	1	1	1	1	0	1	1	0	1	B	0	1	4	0	1	0	0	2	1	1
C	0	0	0	0	1	2	1	0	1	0	C	0	0	1	0	1	1	1	1	1	0
D	14	14	14	14	14	13	14	14	14	13	D	26	25	22	26	24	23	24	24	24	25
MAT	15	15	15	15	14	14	14	15	15	15	MAT	27	26	22	27	25	25	25	24	25	26
RS	94	94	94	94	88	88	87.5	94	94	94	RS	100	96	81	100	93	93	93	89	93	96
HKS	0.9	0.9	0.9	0.9	-0	0.3	-0.1	0.9	0.5	0.9	HKS	1	1	-0	1	0.5	0.7	0.5	-0	0.5	1
POD	1	1	1	1	0	0.3	0	1	0.5	1	POD	1	1	0	1	0.5	0.7	0.5	0	0.5	1
FAR	0.5	0.5	0.5	0.5	1	0	1	0.5	0	0.3	FAR	0	0.5	1	0	0.5	0	0	1	0.5	0.5
CSI	0.5	0.5	0.5	0.5	0	0.3	0	0.5	0.5	0.7	CSI	1	0.5	0	1	0.3	0.7	0.5	0	0.3	0.5
HSS	0.6	0.6	0.6	0.6	-0	0.4	-0.1	0.6	0.6	0.8	HSS	1	0.6	-0	1	0.5	0.8	0.6	-0	0.5	0.6
RMSE	1.5	3.3	3.8	8	6	1.4	0.99	2.8	3.7	4	RMSE	0.2	1.2	1.3	0.2	0.7	0	1.2	0.8	0.6	0.5

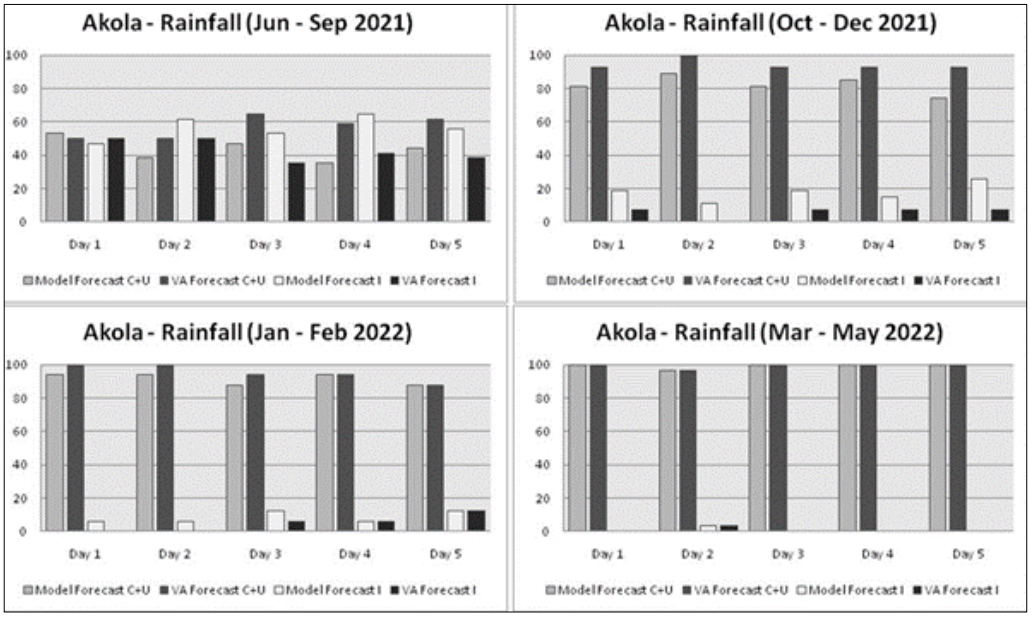

Fig 2: Qualitative accuracy correct+ usable (C+I) and Incorrect (I) for rainfall for Akola

3.1.2 Verification of Rainfall for Amravati

As seen in Table-2 and Figure-3, during the SW Monsoon season of the study period, the model forecasts qualitative efficacy in terms of Correct and Usable was <30% for all the 5 forecasted days, where as those of the value added forecasts were >50% for all the forecasted days except for day 4 where it was observed to be about 40%. From Table-2, it can also be seen that the skill scores for all the 5 days were better for value added forecasts as compared with those of the model forecasts for SW Monsoon 2021. RMSE for all the 5 days w.r.t. value added forecast was also much less than those of the model based forecasts, which shows that the value added forecasts were qualitatively better as compared to the model based forecasts. As seen from Table-2 and Figure-3, qualitative forecast for rainfall during the Post Monsoon season of 2021 were about 80% and above for both model based and value added forecasts. However, the qualitative efficacy of the value added forecast was better than the model based forecasts for all the 5 forecasted days, except day 2 where the efficacy was observed to be the same. From Table-2, it can also be seen that the skill scores for all the 5 days were better for value added forecasts as compared with those of the model forecasts for the Post Monsoon Season of 2021. RMSE for all the 5 days w.r.t. value added forecast was much less than those of the model based forecasts, which shows that the value added forecasts were qualitatively marginally better as compared to the model based forecasts for this season. Table-2 and Figure-3 suggest that in this season, the model based forecasts were qualitatively very effective and the value additions did not make any large difference. Similar to winter season, as seen from Table-2 and Figure-3, in this season, the model based forecasts and the value added forecasts were qualitatively at par.

Table 2: Verification of Forecasted rainfall (Model & Value added) for Amravati

AMRAVATI	MONSOON 2021									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	34	34	34	34	34	34	34	34	34	34
A	30	29	27	27	30	28	30	30	29	32
B	4	3	6	5	2	3	2	2	3	2
C	0	1	1	2	2	2	2	0	2	0
D	0	1	0	0	0	1	0	2	0	0
MAT	30	30	27	27	30	29	30	32	29	32
RS	88.2	88.2	79.4	79.4	88.2	85	88.2	94.1	85.3	94.1
HKS	0.0	0.2	0.0	-0.1	-0.1	0.2	-0.1	0.5	-0.1	0.0
POD	1.0	1.0	1.0	0.9	0.9	0.9	0.9	1.0	0.9	1.0
FAR	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
CSI	0.9	0.9	0.8	0.8	0.9	0.8	0.9	0.9	0.9	0.9
HSS	0.0	0.3	-0.1	-0.1	-0.1	0.2	-0.1	0.6	-0.1	0.0
RMSE	51.9	46.3	26.8	32.0	37.9	10.9	11.2	9.2	11.1	11.5

AMRAVATI	POST MONSOON 2021									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	27	27	27	27	27	27	27	27	27	27
A	3	3	1	3	3	4	4	2	3	4
B	3	2	6	4	6	3	2	6	4	3
C	2	3	1	0	2	1	2	0	0	1
D	19	19	19	20	16	19	19	19	20	19
MAT	22	22	20	23	19	23	23	21	23	23
RS	81.5	81.5	74.1	85.2	70.4	85.2	85.2	77.8	85.2	85.2
HKS	0.5	0.4	0.3	0.8	0.3	0.7	0.6	0.8	0.8	0.7
POD	0.6	0.5	0.5	1.0	0.6	0.8	0.7	1.0	1.0	0.8
FAR	0.5	0.4	0.9	0.6	0.7	0.4	0.3	0.8	0.6	0.4
CSI	0.4	0.4	0.1	0.4	0.3	0.5	0.5	0.3	0.4	0.5
HSS	0.4	0.4	0.1	0.5	0.3	0.6	0.6	0.3	0.5	0.6
RMSE	21.7	8.9	17.3	23.3	16.6	4.2	5.1	3.2	2.0	3.2

AMRAVATI	WINTER 2022									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	16	16	16	16	16	16	16	16	16	16
A	1	1	1	1	1	1	1	1	1	1
B	2	3	2	1	1	0	1	1	1	2
C	1	0	1	0	2	2	0	1	0	0
D	12	12	12	14	12	13	14	13	14	13
MAT	13	13	13	15	13	14	15	14	15	14
RS	81	81	81	94	81	88	93.8	88	94	88
HKS	0.4	0.8	0.4	0.9	0.3	0.3	0.93	0.4	0.9	0.9
POD	0.5	1	0.5	1	0.3	0.3	1	0.5	1	1
FAR	0.7	0.8	0.7	0.5	0.5	0	0.5	0.5	0.5	0.7
CSI	0.3	0.3	0.3	0.5	0.3	0.3	0.5	0.3	0.5	0.3
HSS	0.3	0.3	0.3	0.6	0.3	0.4	0.64	0.4	0.6	0.4
RMSE	6.6	8.8	7.8	17	10	1.6	0.81	1	5.1	8.4

AMRAVATI	PRE MONSOON 2022									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	28	28	28	28	28	28	28	28	28	28
A	0	1	1	0	2	1	0	1	2	0
B	1	4	3	2	1	2	3	1	1	1
C	1	0	1	2	1	0	1	1	1	1
D	26	23	23	24	24	25	24	25	24	26
MAT	26	24	24	24	26	26	24	26	26	26
RS	93	86	86	86	93	93	86	93	93	93
HKS	-0	0.9	0.4	-0	0.6	0.9	-0	0.5	0.6	-0
POD	0	1	0.5	0	0.7	1	0	0.5	0.7	0
FAR	1	0.8	0.8	1	0.3	0.7	1	0.5	0.3	1
CSI	0	0.2	0.2	0	0.5	0.3	0	0.3	0.5	0
HSS	-0	0.3	0.3	-0	0.6	0.5	-0	0.5	0.6	-0
RMSE	0.4	1.7	3.7	1.2	1.6	0.6	1.5	0.7	0.8	0.5

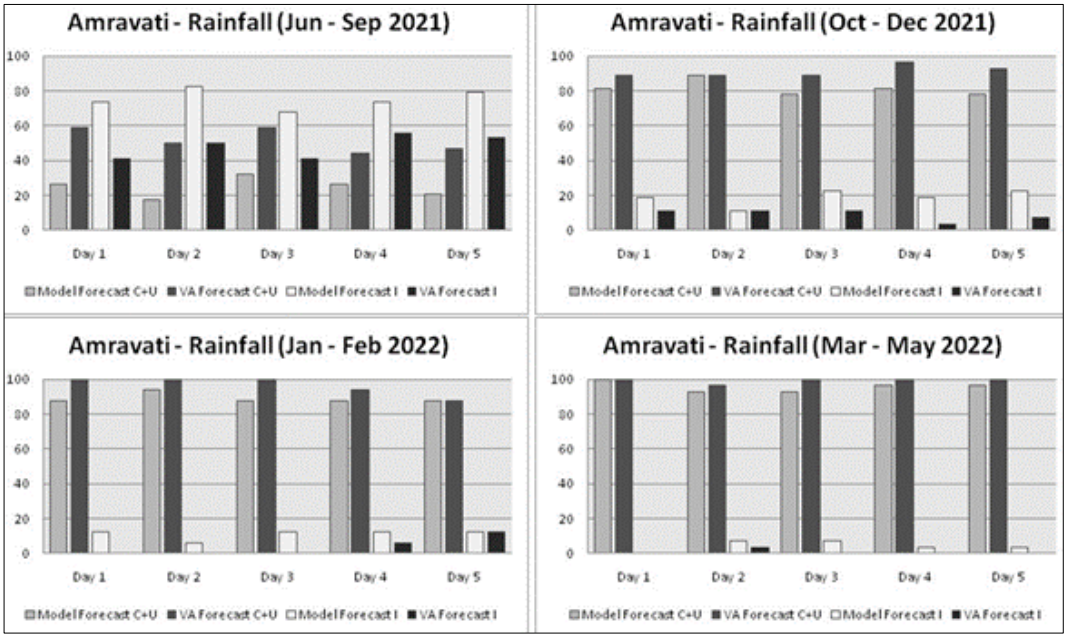

Fig 3: Qualitative accuracy correct+ usable (C+I) and Incorrect (I) for rainfall for Amravati

3.1.3 Verification of Rainfall for Buldhana

As seen in Table-3 and Figure-4, during the SW Monsoon season of the study period, the model forecasts qualitative efficacy in terms of Correct and Usable was <40% for all the 5 forecasted days, where as those of the value added forecasts were >40%. From Table-3, it can also be seen that the skill scores for all the 5 days were better for value added forecasts as compared with those of the model forecasts for the SW Monsoon Season of 2021. RMSE for all the 5 days w.r.t. value added forecast was also much less than those of the model based forecasts.

As seen from Table-3 and Figure-4, the qualitative forecast for rainfall during the Post Monsoon season of 2021 were about 80% and above for both model based and value added forecast and the qualitative efficacy of both model based and value added forecasts were similar.

As seen from Tables-3 and Figure-4, the model based forecasts were qualitatively very effective and the value additions did not make any large difference during winter season as well as the Pre Monsoon season of the study period

Table 3: Verification of Forecasted rainfall (Model & Value added) for Buldhana

BULDHANA	MONSOON 2021									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	34	34	34	34	34	34	34	34	34	34
A	31	30	29	29	29	33	30	29	31	31
B	1	3	5	1	3	1	2	1	1	1
C	2	0	0	4	2	0	1	0	0	3
D	0	1	0	0	0	0	1	4	1	0
MAT	31	31	29	29	29	33	31	33	32	31
RS	91.2	91.2	85.3	85.3	85.3	97	91.2	97.1	94.1	91.2
HKS	-0.1	0.3	0.0	-0.1	-0.1	0.0	0.3	0.8	0.5	-0.1
POD	0.9	1.0	1.0	0.9	0.9	1.0	1.0	1.0	1.0	0.9
FAR	0.0	0.1	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0
CSI	0.9	0.9	0.9	0.9	0.9	1.0	0.9	1.0	1.0	0.9
HSS	0.0	0.4	0.0	0.0	-0.1	0.0	0.4	0.9	0.7	0.0
RMSE	33.2	29.7	16.7	22.6	19.3	14.0	14.8	8.6	13.1	13.7

BULDHANA	POST MONSOON 2021									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	27	27	27	27	27	27	27	27	27	27
A	4	3	2	6	4	5	5	3	3	4
B	2	1	5	0	6	2	1	5	1	4
C	2	3	1	0	0	1	1	0	2	0
D	19	20	19	21	17	19	20	19	21	19
MAT	23	23	21	27	21	24	25	22	24	23
RS	85.2	85.2	77.8	-	77.8	88.9	92.6	81.5	88.9	85.2
HKS	0.6	0.5	0.5	1.0	0.7	0.7	0.8	0.8	0.6	0.8
POD	0.7	0.5	0.7	1.0	1.0	0.8	0.8	1.0	0.6	1.0
FAR	0.3	0.3	0.7	0.0	0.6	0.3	0.2	0.6	0.3	0.5
CSI	0.5	0.4	0.3	1.0	0.4	0.6	0.7	0.4	0.5	0.5
HSS	0.6	0.5	0.3	1.0	0.5	0.7	0.8	0.5	0.6	0.6
RMSE	12.4	7.9	10.9	14.2	14.7	2.7	2.8	2.5	6.8	3.1

BULDHANA	WINTER 2022									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	16	16	16	16	16	16	16	16	16	16
A	1	0	1	0	0	1	0	1	0	1
B	1	0	2	1	1	0	1	1	1	1
C	1	1	0	1	1	2	1	0	1	1
D	13	15	13	14	14	13	14	14	14	13
MAT	14	15	14	14	14	14	14	15	14	14
RS	88	94	88	88	88	88	87.5	94	88	88
HKS	0.4	0	0.9	-0	-0	0.3	-0.1	0.9	-0	0.4
POD	0.5	0	1	0	0	0.3	0	1	0	0.5
FAR	0.5	-	0.7	1	1	0	1	0.5	1	0.5
CSI	0.3	0	0.3	0	0	0.3	0	0.5	0	0.3
HSS	0.4	0	0.4	-0	-0	0.4	-0.1	0.6	-0	0.4
RMSE	1.6	2.3	4.5	11	5.8	1.1	0.88	1	2.9	2.2

BULDHANA	PRE MONSOON 2022									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	27	27	27	27	27	27	27	27	27	27
A	0	0	0	0	0	0	0	0	0	0
B	1	2	4	2	3	0	3	2	3	2
C	0	0	1	0	0	0	0	1	0	0
D	26	25	22	25	24	27	24	24	24	25
MAT	26	25	22	25	24	27	24	24	24	25
RS	96	93	81	93	89	100	89	89	89	93
HKS	-	-	-0	-	-	-	-	-0	-	-
POD	-	-	0	-	-	-	-	0	-	-
FAR	1	1	1	1	1	-	1	1	1	1
CSI	0	0	0	0	0	-	0	0	0	0
HSS	0	0	-0	0	0	-	0	-0	0	0
RMSE	0.8	1.9	1.9	1	1.7	0	1.9	0.8	0.7	0.5

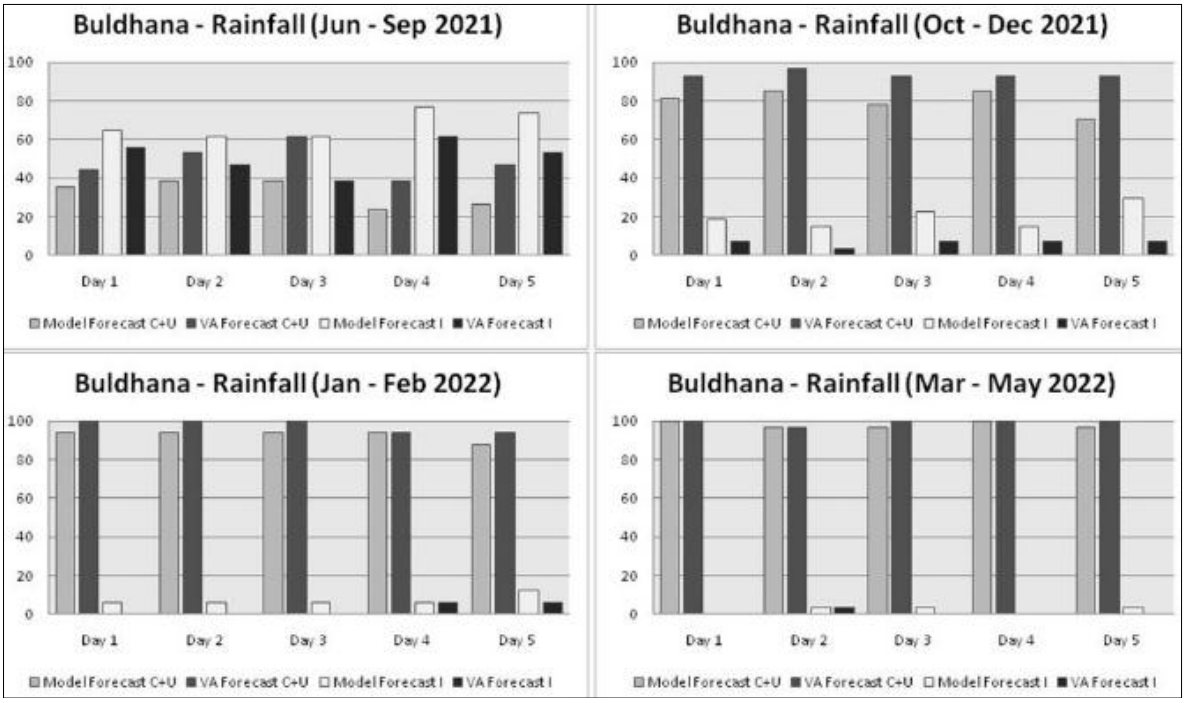

Fig 4: Qualitative accuracy correct+ usable (C+I) and Incorrect (I) for rainfall for Buldhana

3.1.4 Verification of Rainfall for Chandrapur

As seen in Table-4 and Figure-5, during the SW Monsoon season of the study period, the model forecasts qualitative efficacy in terms of Correct and Usable was <40% for all the 5 forecasted days, where as those of the value added forecasts were >40%. From Table-4, it can also be seen that the skill scores for all the 5 days were better for value added forecasts as compared with those of the model forecasts for the SW Monsoon Season of 2021. RMSE for all the 5 days w.r.t. value added forecast was also much less than those of the model based forecasts.

As seen from Table-4 and Figure-5, qualitative forecast for rainfall during the Post Monsoon season of 2021 were about 80% and above for both model based and value added forecast and the qualitative efficacy of both model based and value added forecasts were similar. As seen from Table-4 and Figure-5, during winter season the model based forecasts were qualitatively very effective and the value additions did not make any large difference. Similar to winter season, as seen from Table-4 and Figure-5, the model based forecasts and the value added forecasts for Pre-Monsoon season during the study period were qualitatively at par.

Table 4: Verification of Forecasted rainfall (Model & Value added) for Chandrapur

CHANDRAPUR	MONSOON 2021									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	34	34	34	34	34	34	34	34	34	34
A	30	31	28	29	28	30	31	29	32	30
B	4	3	4	2	4	0	1	3	1	1
C	0	0	1	3	2	0	1	1	1	2
D	0	0	1	0	0	4	2	1	0	1
MAT	30	31	29	29	28	34	33	30	32	31
RS	88.2	91.2	85.3	85.3	82.4	100	97.1	88.2	94.1	91.2
HKS	0.0	0.0	0.2	-0.1	-0.1	1.0	0.6	0.2	0.0	0.4
POD	1.0	1.0	1.0	0.9	0.9	1.0	1.0	1.0	1.0	0.9
FAR	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.0	0.0
CSI	0.9	0.9	0.8	0.9	0.8	1.0	0.9	0.9	0.9	0.9
HSS	0.0	0.0	0.2	-0.1	-0.1	1.0	0.6	0.3	0.0	0.4
RMSE	25.2	28.3	31.4	23.6	30.5	16.1	9.2	14.6	17.5	12.7

CHANDRAPUR	POST MONSOON 2021									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	27	27	27	27	27	27	27	27	27	27
A	5	4	5	4	3	5	4	6	4	3
B	5	4	3	4	4	3	4	3	4	6
C	0	0	1	0	0	0	0	0	0	0
D	17	19	18	19	20	19	19	18	19	18
MAT	22	23	23	23	23	24	23	24	23	21
RS	81.5	85.2	85.2	85.2	85.2	88.9	85.2	88.9	85.2	77.8
HKS	0.8	0.8	0.7	0.8	0.8	0.9	0.8	0.9	0.8	0.8
POD	1.0	1.0	0.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0
FAR	0.5	0.5	0.4	0.5	0.6	0.4	0.5	0.3	0.5	0.7
CSI	0.5	0.5	0.6	0.5	0.4	0.6	0.5	0.7	0.5	0.3
HSS	0.6	0.6	0.6	0.6	0.5	0.7	0.6	0.7	0.6	0.4
RMSE	8.6	10.0	12.2	8.7	13.5	3.4	2.6	4.2	2.6	1.9

CHANDRAPUR	WINTER 2022									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	16	16	16	16	16	16	16	16	16	16
A	2	2	0	2	2	2	1	0	2	1
B	0	2	5	0	2	0	2	3	0	3
C	0	0	1	0	0	0	1	1	0	1
D	14	12	10	14	12	14	12	12	14	11
MAT	16	14	10	16	14	16	13	12	16	12
RS	100	88	63	100	88	100	81.3	75	100	75
HKS	1	0.9	-0	1	0.9	1	0.36	-0	1	0.3
POD	1	1	0	1	1	1	0.5	0	1	0.5
FAR	0	0.5	1	0	0.5	0	0.67	1	0	0.8
CSI	1	0.5	0	1	0.5	1	0.25	0	1	0.2
HSS	1	0.6	-0	1	0.6	1	0.29	-0	1	0.2
RMSE	3.9	10	9.2	6.4	5.1	3	3.78	3.9	1.7	2.7

CHANDRAPUR	PRE MONSOON 2022									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	27	27	27	27	27	27	27	27	27	27
A	0	0	1	0	0	0	0	1	0	0
B	3	5	6	6	9	10	7	5	3	3
C	0	0	0	0	0	0	0	0	0	0
D	24	22	20	21	18	17	20	21	24	24
MAT	24	22	21	21	18	17	20	22	24	24
RS	89	81	78	78	67	63	74	81	89	89
HKS	-	-	0.8	-	-	-	-	0.8	-	-
POD	-	-	1	-	-	-	-	1	-	-
FAR	1	1	0.9	1	1	1	1	0.8	1	1
CSI	0	0	0.1	0	0	0	0	0.2	0	0
HSS	0	0	0.2	0	0	0	0	0.2	0	0
RMSE	1.3	1.7	2.3	1.5	1.8	1.4	1.4	1.4	0.9	0.9

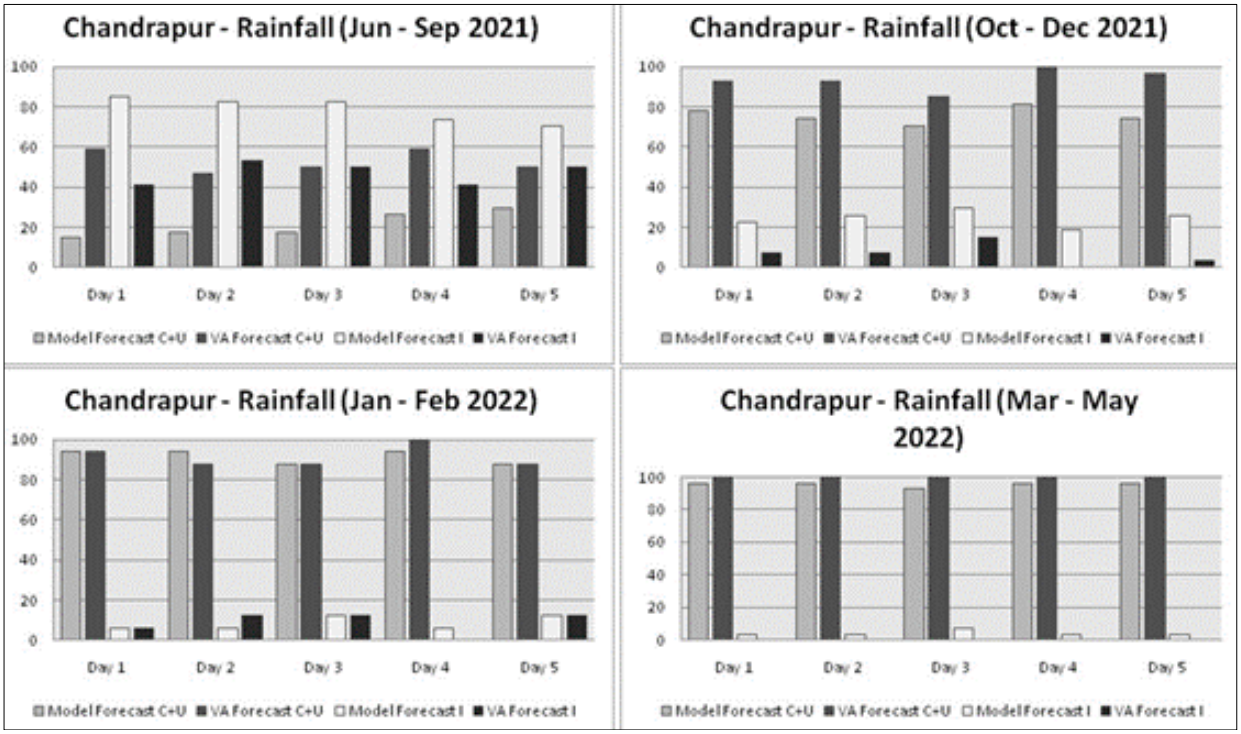

Fig 5: Qualitative accuracy correct+ usable (C+I) and Incorrect (I) for rainfall for Chandrapur

3.1.5 Verification of Rainfall for Gadchiroli

Table-5 and Figure-6 suggest that during the SW Monsoon season of the study period, the model forecasts qualitative efficacy in terms of Correct and Usable was <40% for all the forecasted days except day 5, where as it was slightly above 40%. The forecast efficacy of the value added forecasts were >40% for all the 5 days, though day 5 it was comparable with that of the model based forecast. From Table-5, it can also be seen that RMSE for all the 5 days w.r.t. value added forecast was also much less than those of the model based forecasts.

As seen from Table-5 and Figure-6, qualitative forecast for rainfall during the Post Monsoon season of 2021 were slightly <80% and slightly >80% for value added forecasts. Table-5 and Figure-6, show that during winter season, the model based forecasts were qualitatively very effective and the value additions did not make any large difference. Similar to winter season, as seen from Table-5 and Figure-6, the model based forecasts and the value added forecasts for Pre-Monsoon season during the study period were qualitatively at par.

Table 5: Verification of Forecasted rainfall (Model & Value added) for Gadhchiroli

GADCHIROLI	MONSOON 2021									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	34	34	34	34	34	34	34	34	34	34
A	33	32	27	31	31	33	33	29	32	32
B	1	1	5	0	1	1	0	0	1	1
C	0	1	2	2	2	0	0	2	1	0
D	0	0	0	1	0	0	1	3	0	1
MAT	33	32	27	32	31	33	34	32	32	33
RS	97.1	94.1	79.4	94.1	91.2	97	100.0	94.1	94.1	97.1
HKS	0.0	0.0	-0.1	0.9	-0.1	0.0	1.0	0.9	0.0	0.5
POD	1.0	1.0	0.9	0.9	0.9	1.0	1.0	0.9	1.0	1.0
FAR	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CSI	1.0	0.9	0.8	0.9	0.9	1.0	1.0	0.9	0.9	1.0
HSS	0.0	0.0	-0.1	0.5	0.0	0.0	1.0	0.7	0.0	0.7
RMSE	21.6	30.5	31.2	20.3	34.4	12.2	13.8	16.4	12.2	13.9

GADCHIROLI	POST MONSOON 2021									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	27	27	27	27	27	27	27	27	27	27
A	6	5	6	3	6	6	5	7	3	6
B	4	3	2	5	1	2	3	2	5	4
C	0	1	1	0	0	0	1	0	0	0
D	17	18	18	19	20	19	18	18	19	17
MAT	23	23	24	22	26	25	23	25	22	23
RS	85.2	85.2	88.9	81.5	96.3	92.6	85.2	92.6	81.5	85.2
HKS	0.8	0.7	0.8	0.8	1.0	0.9	0.7	0.9	0.8	0.8
POD	1.0	0.8	0.9	1.0	1.0	1.0	0.8	1.0	1.0	1.0
FAR	0.4	0.4	0.3	0.6	0.1	0.3	0.4	0.2	0.6	0.4
CSI	0.6	0.6	0.7	0.4	0.9	0.8	0.6	0.8	0.4	0.6
HSS	0.7	0.6	0.7	0.5	0.9	0.8	0.6	0.8	0.5	0.7
RMSE	7.9	9.0	12.0	10.7	12.7	3.5	3.1	2.9	2.9	2.5

GADCHIROLI	WINTER 2022									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	16	16	16	16	16	16	16	16	16	16
A	2	2	1	2	2	2	1	1	2	1
B	0	2	4	0	2	0	0	1	0	2
C	0	0	0	0	0	0	1	0	0	1
D	14	12	11	14	12	14	14	14	14	12
MAT	16	14	12	16	14	16	15	15	16	13
RS	100	88	75	100	88	100	93.8	94	100	81
HKS	1	0.9	0.7	1	0.9	1	0.5	0.9	1	0.4
POD	1	1	1	1	1	1	0.5	1	1	0.5
FAR	0	0.5	0.8	0	0.5	0	0	0.5	0	0.7
CSI	1	0.5	0.2	1	0.5	1	0.5	0.5	1	0.3
HSS	1	0.6	0.3	1	0.6	1	0.64	0.6	1	0.3
RMSE	3.7	5.1	8.9	7.8	6.8	1.3	2.1	2.8	1.2	1.9

GADCHIROLI	PRE MONSOON 2022									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	27	27	27	27	27	27	27	27	27	27
A	1	1	2	2	2	3	1	2	2	1
B	2	4	5	4	7	6	7	4	1	1
C	2	0	0	0	0	0	0	0	0	1
D	22	22	20	21	18	18	19	21	24	24
MAT	23	23	22	23	20	21	20	23	26	25
RS	85	85	81	85	74	78	74	85	96	93
HKS	0.3	0.8	0.8	0.8	0.7	0.8	0.7	0.8	1	0.5
POD	0.3	1	1	1	1	1	1	1	1	0.5
FAR	0.7	0.8	0.7	0.7	0.8	0.7	0.9	0.7	0.3	0.5
CSI	0.2	0.2	0.3	0.3	0.2	0.3	0.1	0.3	0.7	0.3
HSS	0.3	0.3	0.4	0.4	0.3	0.4	0.2	0.4	0.8	0.5
RMSE	0.9	1.7	2	1.3	1.8	1.2	2.6	1.2	0.6	0.7

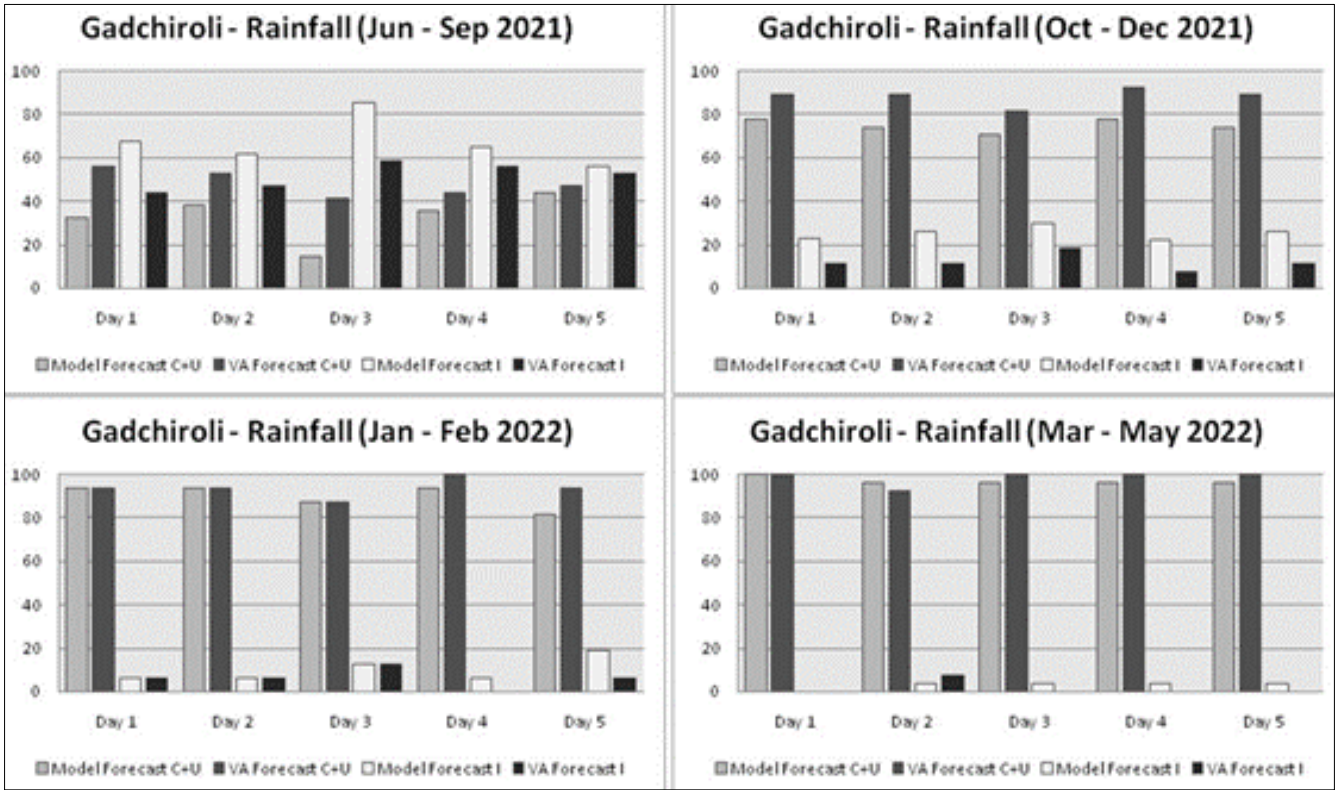

Fig 6: Qualitative accuracy correct+ usable (C+I) and Incorrect (I) for rainfall for Gadhchiroli

3.1.6 Verification of Rainfall for Gondia

It can be seen from Table-6 and Figure-7 that during the SW Monsoon season of the study period, the value added forecasts qualitative efficacy in terms of Correct and Usable was about 50-60% for days 1, 2, 3 and 5, much higher than those of the model based forecasts, whereas for day 4, it was slightly less than the model forecast, however both were <40%. From Table-6, however, it can be seen that RMSE for all the 5 days w.r.t. value added forecast was comparatively less than those of the model based forecasts. As seen from Tables-6 and Figures-7, qualitative forecast for rainfall during the Post Monsoon season Winter season and Pre-Monsoon season of the study period, the model based forecasts were qualitatively very effective (>80%) and the value additions did not make any large difference, however value added forecasts were slightly better.

Table 6: Verification of Forecasted rainfall (Model & Value added) for Gondia

GONDIA	MONSOON 2021									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	34	34	34	34	34	34	34	34	34	34
A	29	31	30	30	28	29	31	30	31	29
B	5	3	3	3	4	2	0	2	2	5
C	0	0	0	1	1	0	1	1	0	0
D	0	0	1	0	1	3	2	1	1	0
MAT	29	31	31	30	29	32	33	31	32	29
RS	85.3	91.2	91.2	88.2	85.3	94	97.1	91.2	94.1	85.3
HKS	0.0	0.0	0.3	0.0	0.2	0.6	1.0	0.3	0.3	0.0
POD	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
FAR	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1
CSI	0.9	0.9	0.9	0.9	0.8	0.9	1.0	0.9	0.9	0.9
HSS	0.0	0.0	0.4	0.0	0.2	0.7	0.8	0.4	0.5	0.0
RMSE	28.0	38.3	27.2	23.3	22.0	11.4	12.1	14.8	16.8	11.9

GONDIA	POST MONSOON 2021									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	27	27	27	27	27	27	27	27	27	27
A	2	3	5	3	3	2	4	5	3	4
B	3	3	2	4	3	3	3	3	4	3
C	2	2	0	1	1	2	1	0	1	0
D	20	19	20	19	20	20	19	19	19	20
MAT	22	22	25	22	23	22	23	24	22	24
RS	81.5	81.5	92.6	81.5	85.2	81.5	85.2	88.9	81.5	88.9
HKS	0.4	0.5	0.9	0.6	0.6	0.4	0.7	0.9	0.6	0.9
POD	0.5	0.6	1.0	0.8	0.8	0.5	0.8	1.0	0.8	1.0
FAR	0.6	0.5	0.3	0.6	0.5	0.6	0.4	0.4	0.6	0.4
CSI	0.3	0.4	0.7	0.4	0.4	0.3	0.5	0.6	0.4	0.6
HSS	0.3	0.4	0.8	0.4	0.5	0.3	0.6	0.7	0.4	0.7
RMSE	10.0	8.8	12.6	12.0	12.1	3.8	4.4	3.0	2.3	2.7

GONDIA	WINTER 2022									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	16	16	16	16	16	16	16	16	16	16
A	0	2	1	1	1	0	1	0	1	0
B	3	1	4	2	3	2	2	3	1	3
C	1	0	0	1	0	1	1	1	1	1
D	12	13	11	12	12	13	12	12	13	12
MAT	12	15	12	13	13	13	13	12	14	12
RS	75	94	75	81	81	81	81.3	75	88	75
HKS	-0	0.9	0.7	0.4	0.8	-0.1	0.36	-0	0.4	-0
POD	0	1	1	0.5	1	0	0.5	0	0.5	0
FAR	1	0.3	0.8	0.7	0.8	1	0.67	1	0.5	1
CSI	0	0.7	0.2	0.3	0.3	0	0.25	0	0.3	0
HSS	-0	0.8	0.3	0.3	0.3	-0.1	0.29	-0	0.4	-0
RMSE	5.6	3.5	5.8	5	5.6	2.4	0.74	3.9	2.6	7.4

GONDIA	PRE MONSOON 2022									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	27	27	27	27	27	27	27	27	27	27
A	0	0	0	0	1	1	0	0	1	1
B	3	5	5	3	2	6	6	6	2	1
C	1	1	1	2	1	0	1	1	1	0
D	23	21	21	22	23	20	20	20	23	25
MAT	23	21	21	22	24	21	20	20	24	26
RS	85	78	78	81	89	78	74	74	89	96
HKS	-0	-0	-0	-0	0.4	0.8	-0	-0	0.4	1
POD	0	0	0	0	0.5	1	0	0	0.5	1
FAR	1	1	1	1	0.7	0.9	1	1	0.7	0.5
CSI	0	0	0	0	0.3	0.1	0	0	0.3	0.5
HSS	-0	-0	-0	-0	0.3	0.2	-0	-0	0.3	0.6
RMSE	1	0.9	3.9	6.3	1.1	1.2	1.1	1.1	0.8	0.7

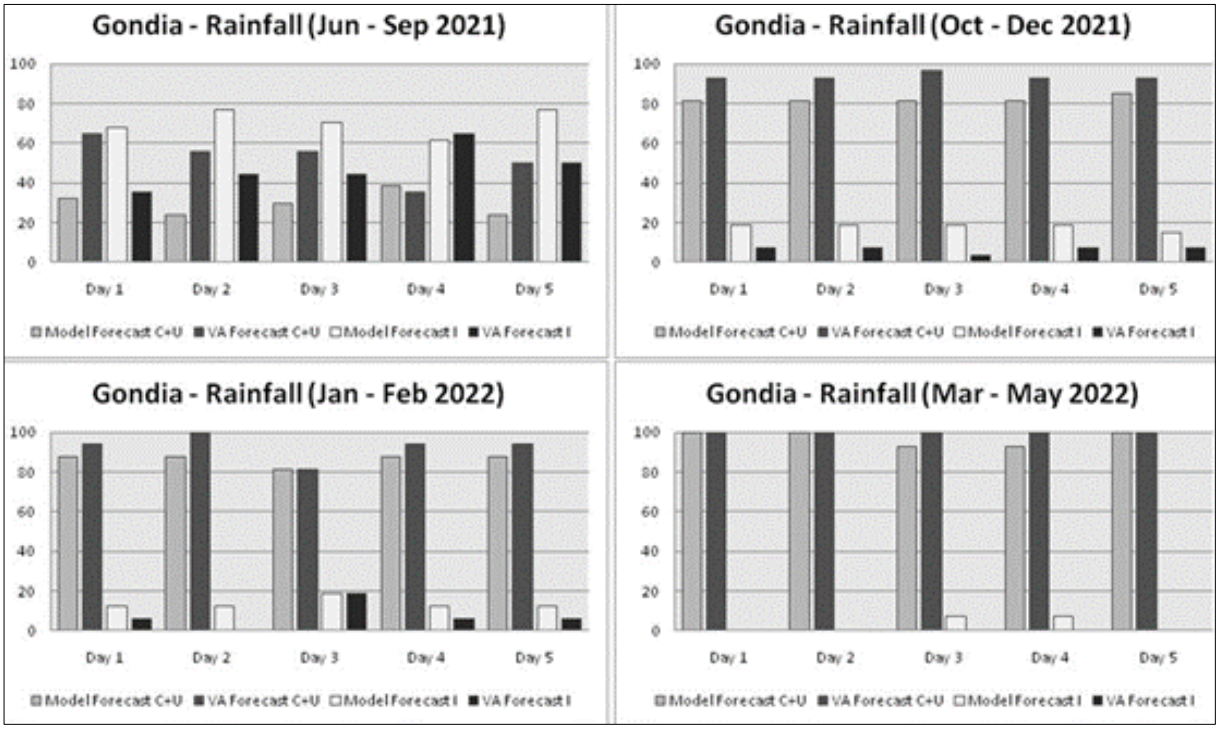

Fig 7: Qualitative accuracy correct+ usable (C+I) and Incorrect (I) for rainfall for Gondia

3.1.7 Verification of Rainfall for Nagpur

Table-7 and Figure-8 suggest that during the SW Monsoon season of the study period, the model forecasts qualitative efficacy in terms of Correct and Usable was <40% for all the 5 forecasted days. The forecast efficacy of the value added forecasts were >40% for all the 5 days, with 62% in day 2, 58% in day 3, and 54% in day 5. From Table-7, it can also be seen that RMSE for all the 5 days w.r.t. value added forecast was also much less than those of the model based forecasts, showing better qualitative efficacy of the forecasts after value addition. As seen from Table-7 and Figure-8, qualitative forecast for rainfall during the Post Monsoon season of 2021 were slightly <80% based on model forecasts only on day 5. Rest of the days the model based forecasts were >=80%. However, the value added forecasts exhibited better results. Table-7 and Figure-8, show that during winter season, the model based forecasts were qualitatively very effective and the value additions did not make any large difference. Similar to winter Similarly, as seen from Table-7 and Figure-8, the model based forecasts and the value added forecasts for Pre-Monsoon season during the study period were qualitatively at par.

Table 7: Verification of Forecasted rainfall (Model & Value added) for Nagpur

NAGPUR	MONSOON 2021									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	34	34	34	34	34	34	34	34	34	34
A	32	33	28	32	31	32	33	30	32	32
B	2	1	4	1	1	1	1	1	0	2
C	0	0	2	1	1	0	0	0	1	0
D	0	0	0	0	1	1	0	3	1	0
MAT	32	33	28	32	32	33	33	33	33	32
RS	94.1	97.1	82.4	94.1	94.1	97	97.1	97.1	97.1	94.1
HKS	0.0	0.0	-0.1	0.0	0.5	0.5	0.0	0.8	1.0	0.0
POD	1.0	1.0	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0
FAR	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
CSI	0.9	1.0	0.8	0.9	0.9	1.0	1.0	1.0	1.0	0.9
HSS	0.0	0.0	-0.1	0.0	0.5	0.7	0.0	0.8	0.7	0.0
RMSE	30.2	37.8	24.3	27.7	31.5	13.0	8.2	9.6	13.9	11.3

NAGPUR	POST MONSOON 2021									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	27	27	27	27	27	27	27	27	27	27
A	3	3	2	4	4	4	4	4	4	4
B	2	3	4	2	5	1	2	3	2	3
C	2	2	2	0	0	1	1	0	0	0
D	20	19	19	21	18	21	20	20	21	20
MAT	23	22	21	25	22	25	24	24	25	24
RS	85.2	81.5	77.8	92.6	81.5	92.6	88.9	88.9	92.6	88.9
HKS	0.5	0.5	0.3	0.9	0.8	0.8	0.7	0.9	0.9	0.9
POD	0.6	0.6	0.5	1.0	1.0	0.8	0.8	1.0	1.0	1.0
FAR	0.4	0.5	0.7	0.3	0.6	0.2	0.3	0.4	0.3	0.4
CSI	0.4	0.4	0.3	0.7	0.4	0.7	0.6	0.6	0.7	0.6
HSS	0.5	0.4	0.3	0.8	0.5	0.8	0.7	0.7	0.8	0.7
RMSE	17.4	8.2	12.5	12.8	10.2	3.9	2.5	2.4	2.9	2.3

NAGPUR	WINTER 2022									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	16	16	16	16	16	16	16	16	16	16
A	2	2	1	2	2	3	1	1	2	1
B	1	2	2	0	2	0	1	2	0	3
C	1	0	1	1	0	0	1	1	1	1
D	12	12	12	13	12	13	13	12	13	11
MAT	14	14	13	15	14	16	14	13	15	12
RS	88	88	81	94	88	100	87.5	81	94	75
HKS	0.6	0.9	0.4	0.7	0.9	1	0.43	0.4	0.7	0.3
POD	0.7	1	0.5	0.7	1	1	0.5	0.5	0.7	0.5
FAR	0.3	0.5	0.7	0	0.5	0	0.5	0.7	0	0.8
CSI	0.5	0.5	0.3	0.7	0.5	1	0.33	0.3	0.7	0.2
HSS	0.6	0.6	0.3	0.8	0.6	1	0.43	0.3	0.8	0.2
RMSE	7.1	3.6	10	11	8.9	2.5	2.42	3.3	2.8	7.4

NAGPUR	PRE MONSOON 2022									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	27	27	27	27	27	27	27	27	27	27
A	1	2	1	1	0	2	1	1	1	0
B	2	2	5	4	5	8	3	4	2	3
C	1	1	0	0	1	0	2	0	0	1
D	23	22	21	22	21	17	21	22	24	23
MAT	24	24	22	23	21	19	22	23	25	23
RS	89	89	81	85	78	70	81	85	93	85
HKS	0.4	0.6	0.8	0.8	-0	0.7	0.2	0.8	0.9	-0
POD	0.5	0.7	1	1	0	1	0.3	1	1	0
FAR	0.7	0.5	0.8	0.8	1	0.8	0.8	0.8	0.7	1
CSI	0.3	0.4	0.2	0.2	0	0.2	0.2	0.2	0.3	0
HSS	0.3	0.5	0.2	0.3	-0	0.2	0.2	0.3	0.5	-0
RMSE	1.9	1	2.5	3.2	1.3	1.3	0.9	1.1	0.8	0.8

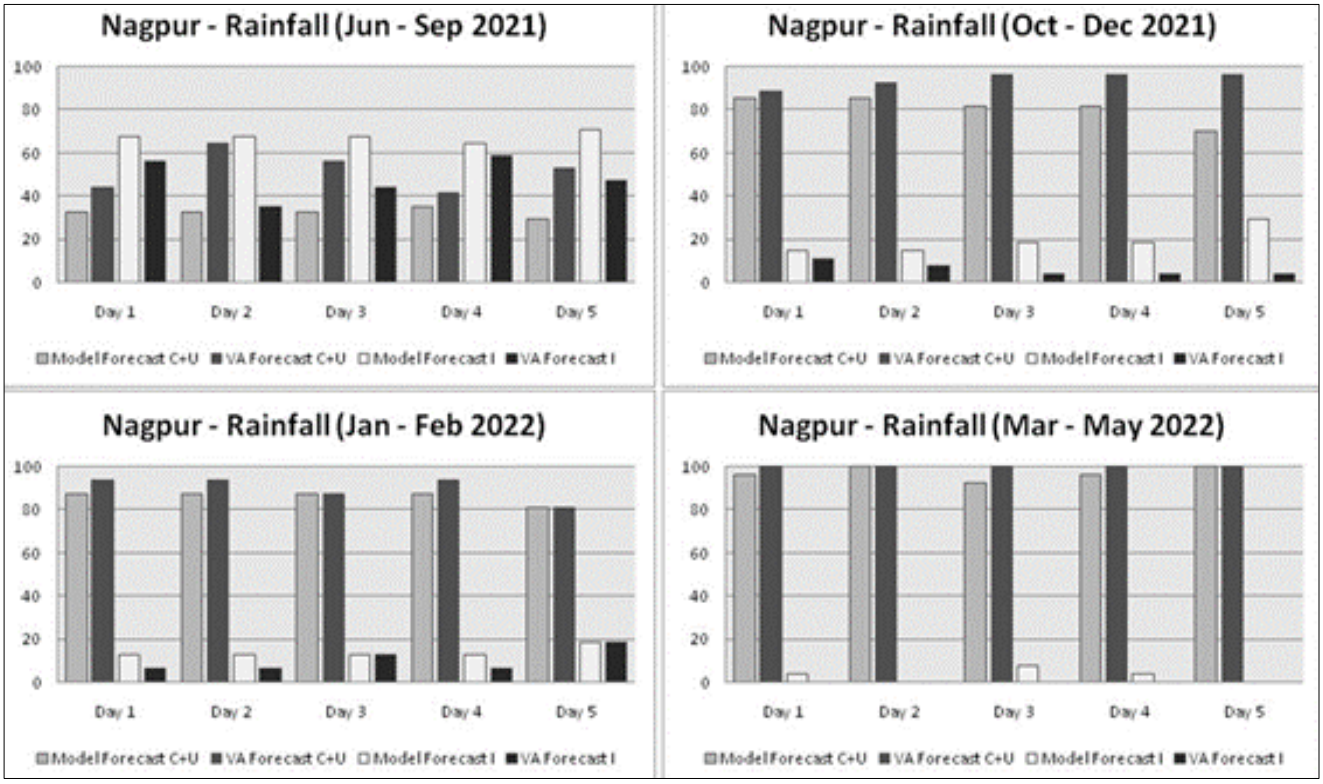

Fig 8: Qualitative accuracy correct +usable (C+I) and Incorrect (I) for rainfall for Nagpur

3.1.8 Verification of Rainfall for Wardha

It can be seen from Table-8 and Figure-9 that during the SW Monsoon season of the study period, the value added forecasts qualitative efficacy in terms of Correct and Usable was about 65% in day 1, 78% in day 2, 58% in day 3, 44% in da 4 and 60% in day 5 whereas the qualitative efficacy of the model based forecasts during this season was <40% for all the 5 forecasted days. From Table-8, it can also be seen that RMSE for all the 5 days w.r.t. value added forecast was comparatively much less than those of the model based forecasts showing better skills of the value added forecast. As seen from Tables-8 and Figure-9, qualitative forecast for rainfall during the Post Monsoon season Winter season and Pre-Monsoon season of the study period, the model based forecasts were qualitatively very effective (>80%) and the value additions did not make any large difference.

Table 8: Verification of Forecasted rainfall (Model & Value added) for Wardha

WARDHA	MONSOON 2021									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	34	34	34	34	34	34	34	34	34	34
A	31	31	28	26	29	31	31	29	29	32
B	3	3	4	5	2	1	0	3	3	0
C	0	0	1	3	3	1	1	1	2	1
D	0	0	1	0	0	1	2	1	0	1
MAT	31	31	29	26	29	32	33	30	29	33
RS	91.2	91.2	85.3	76.5	85.3	94	97.1	88.2	85.3	97.1
HKS	0.0	0.0	0.2	-0.1	-0.1	0.5	1.0	0.2	-0.1	1.0
POD	1.0	1.0	1.0	0.9	0.9	1.0	1.0	1.0	0.9	1.0
FAR	0.1	0.1	0.1	0.2	0.1	0.0	0.0	0.1	0.1	0.0
CSI	0.9	0.9	0.8	0.8	0.9	0.9	1.0	0.9	0.9	1.0
HSS	0.0	0.0	0.2	-0.1	-0.1	0.5	0.8	0.3	-0.1	0.7
RMSE	26.1	44.9	22.9	20.6	31.3	10.4	7.3	9.8	10.9	12.4

WARDHA	POST MONSOON 2021									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	27	27	27	27	27	27	27	27	27	27
A	3	3	3	3	5	4	4	3	3	5
B	2	2	3	3	4	1	2	4	3	2
C	2	2	0	0	0	1	1	0	0	0
D	20	20	21	21	18	21	20	20	21	20
MAT	23	23	24	24	23	25	24	23	24	25
RS	85.2	85.2	88.9	88.9	85.2	92.6	88.9	85.2	88.9	92.6
HKS	0.5	0.5	0.9	0.9	0.8	0.8	0.7	0.8	0.9	0.9
POD	0.6	0.6	1.0	1.0	1.0	0.8	0.8	1.0	1.0	1.0
FAR	0.4	0.4	0.5	0.5	0.4	0.2	0.3	0.6	0.5	0.3
CSI	0.4	0.4	0.5	0.5	0.6	0.7	0.6	0.4	0.5	0.7
HSS	0.5	0.5	0.6	0.6	0.6	0.8	0.7	0.5	0.6	0.8
RMSE	16.5	9.3	12.2	13.4	10.4	3.7	1.4	5.2	1.3	1.8

WARDHA	WINTER 2022									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	16	16	16	16	16	16	16	16	16	16
A	2	1	1	2	1	2	1	1	2	1
B	0	2	2	0	3	1	1	2	0	2
C	0	0	0	0	0	0	0	0	0	0
D	14	13	13	14	12	13	14	13	14	13
MAT	16	14	14	16	13	15	15	14	16	14
RS	100	88	88	100	81	94	93.8	88	100	88
HKS	1	0.9	0.9	1	0.8	0.9	0.93	0.9	1	0.9
POD	1	1	1	1	1	1	1	1	1	1
FAR	0	0.7	0.7	0	0.8	0.3	0.5	0.7	0	0.7
CSI	1	0.3	0.3	1	0.3	0.7	0.5	0.3	1	0.3
HSS	1	0.4	0.4	1	0.3	0.8	0.64	0.4	1	0.4
RMSE	4	2.3	9.7	11	8.4	1.1	0.92	2	3.8	5.6

WARDHA	PRE MONSOON 2022									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	27	27	27	27	27	27	27	27	27	27
A	0	2	1	0	0	3	1	1	1	0
B	2	2	4	3	4	4	2	2	3	3
C	1	1	1	2	1	2	2	1	0	1
D	24	22	21	22	22	18	22	23	23	23
MAT	24	24	22	22	22	21	23	24	24	23
RS	89	89	81	81	81	78	85	89	89	85
HKS	-0	0.6	0.3	-0	-0	0.4	0.3	0.4	0.9	-0
POD	0	0.7	0.5	0	0	0.6	0.3	0.5	1	0
FAR	1	0.5	0.8	1	1	0.6	0.7	0.7	0.8	1
CSI	0	0.4	0.2	0	0	0.3	0.2	0.3	0.3	0
HSS	-0	0.5	0.2	-0	-0	0.4	0.3	0.3	0.4	-0
RMSE	0.7	0.9	2	0.8	1.3	1.2	0.8	1	0.9	0.6

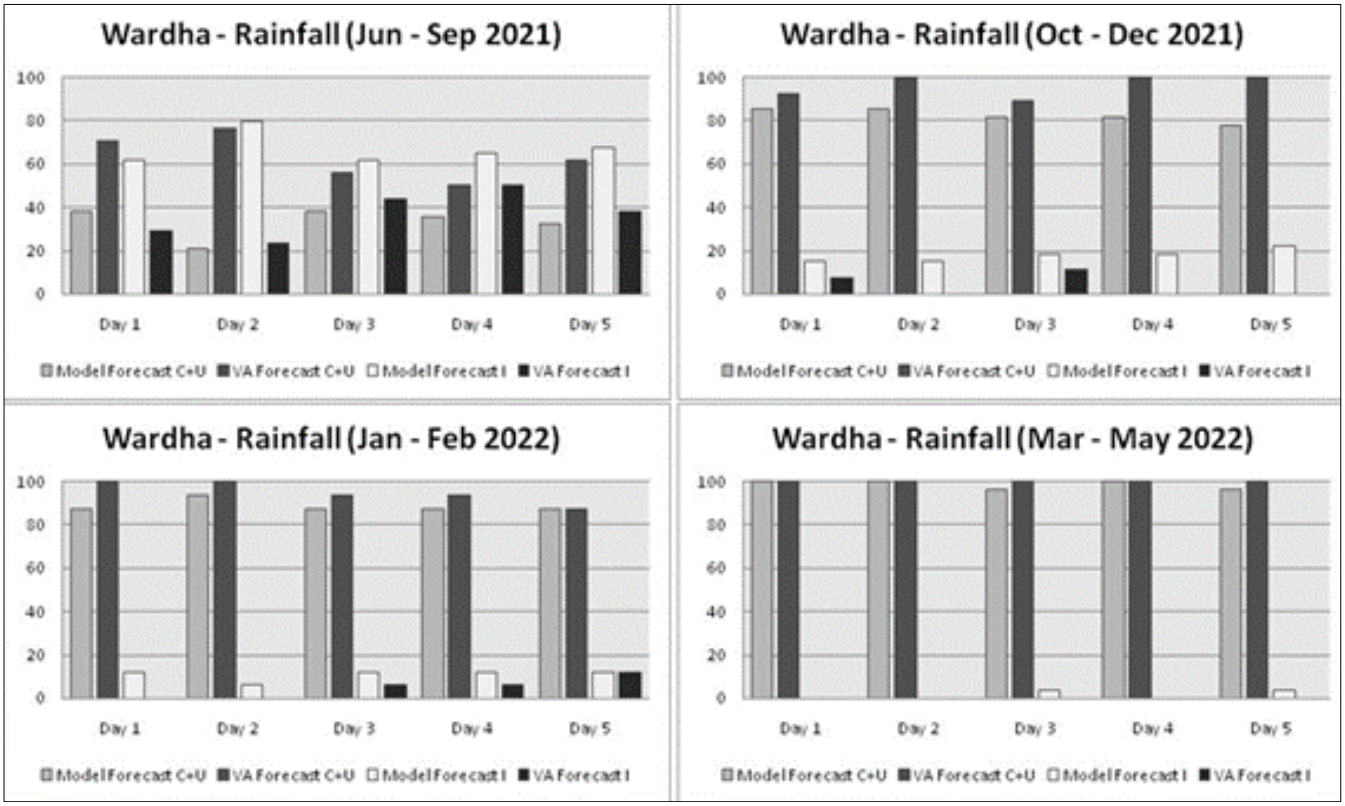

Fig 9: Qualitative accuracy correct+ usable (C+I) and Incorrect (I) for rainfall for Wardha

3.1.9 Verification of Rainfall for Washim

As seen from Table-9 and Figure-10 that during the SW Monsoon season of the study period, the value added forecasts qualitative efficacy was almost at par or slightly above par as compared to the model based forecasts. From Table-9, it can however be seen that RMSE for all the 5 days w.r.t. value added forecast was comparatively less than those of the model based forecasts. As seen from Table-9 and Figure-10, qualitative forecast for rainfall during the Post Monsoon season Winter season and Pre-Monsoon season of the study period, the model based forecasts were qualitatively very effective (about 80% and above) and the value additions did not make very large difference.

Table 9: Verification of Forecasted rainfall (Model & Value added) for Washim

WASHIM	MONSOON 2021										WASHIM	POST MONSOON 2021									
	Model Forecast					Value Added Forecast						Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5		Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	34	34	34	34	34	34	34	34	34	34	N	27	27	27	27	27	27	27	27	27	27
A	30	27	25	27	28	30	29	25	31	31	A	5	2	2	3	2	1	4	3	3	3
B	3	4	9	3	3	3	2	9	0	2	B	2	2	5	2	6	0	2	5	2	5
C	1	2	0	4	3	1	1	0	2	1	C	0	2	1	0	1	4	0	0	0	0
D	0	1	0	0	0	1	2	0	1	0	D	20	21	19	22	18	22	21	19	22	19
MAT	30	28	25	27	28	31	31	25	32	31	MAT	25	23	21	25	20	23	25	22	25	22
RS	88.2	82.4	73.5	79.4	82.4	91	91.2	73.5	94.1	91.2	RS	92.6	85.2	77.8	92.6	74.1	85.2	92.6	81.5	92.6	81.5
HKS	0.0	0.1	0.0	-0.1	-0.1	0.2	0.5	0.0	0.9	0.0	HKS	0.9	0.4	0.5	0.9	0.4	0.2	0.9	0.8	0.9	0.8
POD	1.0	0.9	1.0	0.9	0.9	1.0	1.0	1.0	0.9	1.0	POD	1.0	0.5	0.7	1.0	0.7	0.2	1.0	1.0	1.0	1.0
FAR	0.1	0.1	0.3	0.1	0.1	0.1	0.1	0.3	0.0	0.1	FAR	0.3	0.5	0.7	0.4	0.8	0.0	0.3	0.6	0.4	0.6
CSI	0.9	0.8	0.7	0.8	0.8	0.9	0.9	0.7	0.9	0.9	CSI	0.7	0.3	0.3	0.6	0.2	0.2	0.7	0.4	0.6	0.4
HSS	0.0	0.2	0.0	-0.1	-0.1	0.3	0.5	0.0	0.5	0.0	HSS	0.8	0.4	0.3	0.7	0.2	0.3	0.8	0.5	0.7	0.5
RMSE	26.4	30.0	13.9	18.8	18.9	15.9	12.5	13.4	14.6	11.0	RMSE	8.7	11.2	8.3	9.9	8.4	1.2	8.4	3.4	9.4	1.8
WASHIM	WINTER 2022										WASHIM	PRE MONSOON 2022									
	Model Forecast					Value Added Forecast						Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5		Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	16	16	16	16	16	16	16	16	16	16	N	27	27	27	27	27	27	27	27	27	27
A	1	1	0	0	0	1	1	0	1	1	A	0	0	0	0	0	0	0	0	0	0
B	1	1	1	1	1	0	1	1	0	1	B	1	3	4	1	4	0	3	2	3	3
C	1	0	1	1	1	0	0	1	1	1	C	0	0	1	0	0	0	0	1	0	0
D	13	14	14	14	14	15	14	14	14	13	D	26	24	22	26	23	27	24	24	24	24
MAT	14	15	14	14	14	16	15	14	15	14	MAT	26	24	22	26	23	27	24	24	24	24
RS	88	94	88	88	88	100	93.8	88	94	88	RS	96	89	81	96	85	100	89	89	89	89
HKS	0.4	0.9	-0	-0	-0	1	0.93	-0	0.5	0.4	HKS	-	-	-0	-	-	-	-	-0	-	-
POD	0.5	1	0	0	0	1	1	0	0.5	0.5	POD	-	-	0	-	-	-	-	0	-	-
FAR	0.5	0.5	1	1	1	0	0.5	1	0	0.5	FAR	1	1	1	1	1	-	1	1	1	1
CSI	0.3	0.5	0	0	0	1	0.5	0	0.5	0.3	CSI	0	0	0	0	0	-	0	0	0	0
HSS	0.4	0.6	-0	-0	-0	1	0.64	-0	0.6	0.4	HSS	0	0	-0	0	0	-	0	-0	0	0
RMSE	1.8	3.3	4.4	6.8	5.2	0	1.4	1.4	3	2.9	RMSE	0.6	2.2	1.1	0.2	2.2	0	1.4	0.9	0.6	0.7

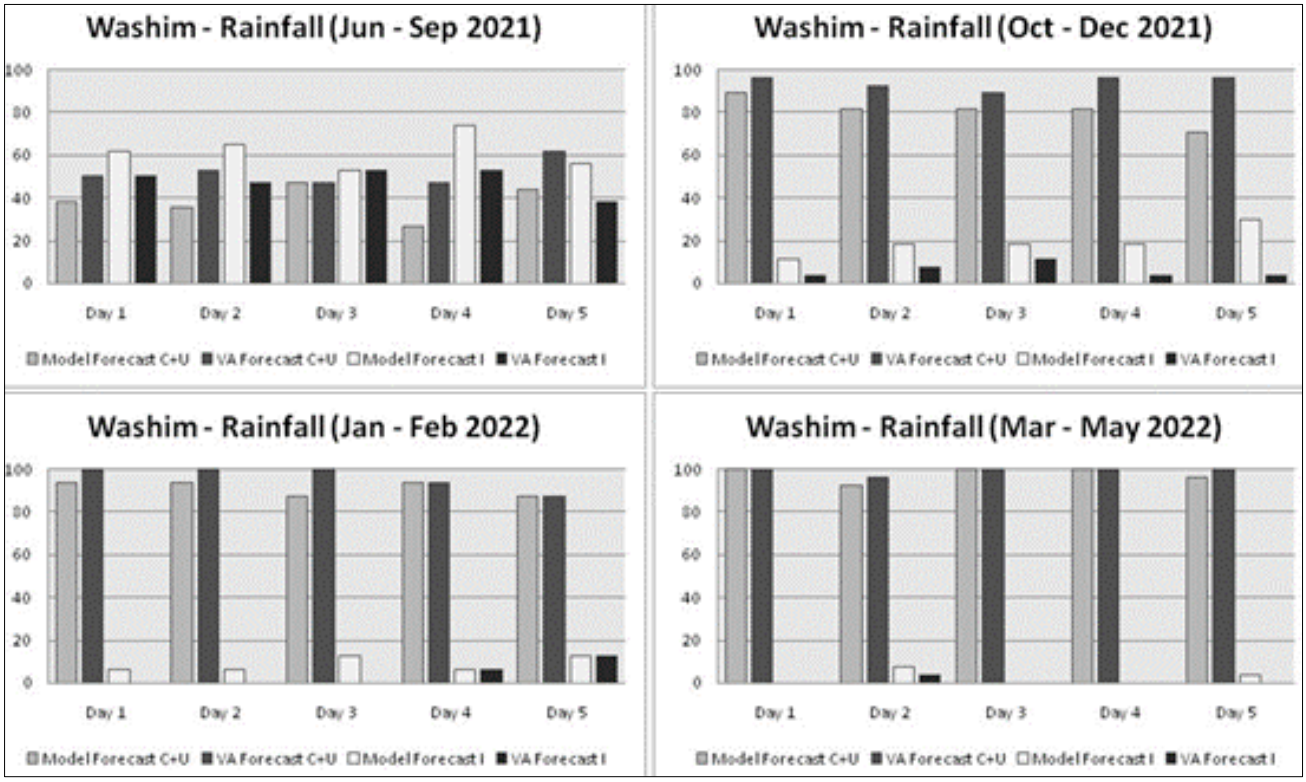

Fig 10: Qualitative accuracy correct +usable (C+I) and Incorrect (I) for rainfall for Washim

3.1.10 Verification of Rainfall for Yeotmal

As seen in Table-10 and Figure-11, similar to all the other districts of Vidarbha, the forecast efficacy was better based on value addition as compared to the model based for all the 5 forecasted days for SW Monsoon season of the study period. From Table-10, it can be seen that RMSE for all the 5 days w.r.t. value added forecast was also much less than those of the model based forecasts. As seen from Table-10 and Figure-11, the qualitative forecast for rainfall during the Post Monsoon season of 2021 were about 80% and above for both model based and value added forecast and the qualitative efficacy of both model based and value added forecasts were similar. It is also evident from Tables-10 and Figure-11, the model based forecasts were qualitatively very effective and the value additions did not make any large difference during winter season as well as the Pre Monsoon season of the study period.

Table 10: Verification of Forecasted rainfall (Model & Value added) for Yeotmal

YEOTMAL	MONSOON 2021									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	34	34	34	34	34	34	34	34	34	34
A	31	33	30	31	30	31	33	31	32	32
B	3	1	3	2	1	1	1	0	1	0
C	0	0	1	1	2	0	0	3	1	1
D	0	0	0	0	1	2	0	1	0	1
MAT	31	33	30	31	31	33	33	32	32	33
RS	91.2	97.1	88.2	91.2	91.2	97	97.1	94.1	94.1	97.1
HKS	0.0	0.0	0.0	0.0	0.4	0.7	0.0	0.9	0.0	1.0
POD	1.0	1.0	1.0	1.0	0.9	1.0	1.0	0.9	1.0	1.0
FAR	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
CSI	0.9	1.0	0.9	0.9	0.9	1.0	1.0	0.9	0.9	1.0
HSS	0.0	0.0	0.0	0.0	0.4	0.8	0.0	0.4	0.0	0.7
RMSE	22.6	44.2	25.8	21.8	33.9	12.4	13.3	11.8	11.7	12.5

YEOTMAL	POST MONSOON 2021									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	27	27	27	27	27	27	27	27	27	27
A	5	5	5	4	4	5	5	6	3	4
B	5	3	4	3	6	3	2	3	3	4
C	0	0	1	0	0	0	0	0	1	0
D	17	19	17	20	17	19	20	18	20	19
MAT	22	24	22	24	21	24	25	24	23	23
RS	81.5	88.9	81.5	88.9	77.8	88.9	92.6	88.9	85.2	85.2
HKS	0.8	0.9	0.6	0.9	0.7	0.9	0.9	0.9	0.6	0.8
POD	1.0	1.0	0.8	1.0	1.0	1.0	1.0	1.0	0.8	1.0
FAR	0.5	0.4	0.4	0.4	0.6	0.4	0.3	0.3	0.5	0.5
CSI	0.5	0.6	0.5	0.6	0.4	0.6	0.7	0.7	0.4	0.5
HSS	0.6	0.7	0.5	0.7	0.5	0.7	0.8	0.7	0.5	0.6
RMSE	9.0	13.0	12.8	9.8	13.4	3.4	2.6	2.3	4.2	3.0

YEOTMAL	WINTER 2022									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	16	16	16	16	16	16	16	16	16	16
A	2	2	1	2	2	2	1	1	2	1
B	1	2	3	0	2	0	1	2	0	2
C	0	0	1	0	0	0	1	1	0	1
D	13	12	11	14	12	14	13	12	14	12
MAT	15	14	12	16	14	16	14	13	16	13
RS	94	88	75	100	88	100	87.5	81	100	81
HKS	0.9	0.9	0.3	1	0.9	1	0.43	0.4	1	0.4
POD	1	1	0.5	1	1	1	0.5	0.5	1	0.5
FAR	0.3	0.5	0.8	0	0.5	0	0.5	0.7	0	0.7
CSI	0.7	0.5	0.2	1	0.5	1	0.33	0.3	1	0.3
HSS	0.8	0.6	0.2	1	0.6	1	0.43	0.3	1	0.3
RMSE	6.5	9.9	9.8	8.7	9.6	2	2.58	3.6	2.4	3.5

YEOTMAL	PRE MONSOON 2022									
	Model Forecast					Value Added Forecast				
	Day1	Day2	Day3	Day4	Day5	Day1	Day2	Day3	Day4	Day5
N	27	27	27	27	27	27	27	27	27	27
A	1	1	1	3	0	3	0	0	1	0
B	3	5	6	4	8	3	3	2	3	3
C	2	1	2	0	1	0	2	3	2	1
D	21	20	18	20	18	21	22	22	21	23
MAT	22	21	19	23	18	24	22	22	22	23
RS	81	78	70	85	67	89	81	81	81	85
HKS	0.2	0.3	0.1	0.8	-0	0.9	-0	-0	0.2	-0
POD	0.3	0.5	0.3	1	0	1	0	0	0.3	0
FAR	0.8	0.8	0.9	0.6	1	0.5	1	1	0.8	1
CSI	0.2	0.1	0.1	0.4	0	0.5	0	0	0.2	0
HSS	0.2	0.2	0.1	0.5	-0	0.6	-0	-0	0.2	-0
RMSE	1	2.3	2.8	7.3	2.2	1.1	1	0.9	0.8	0.8

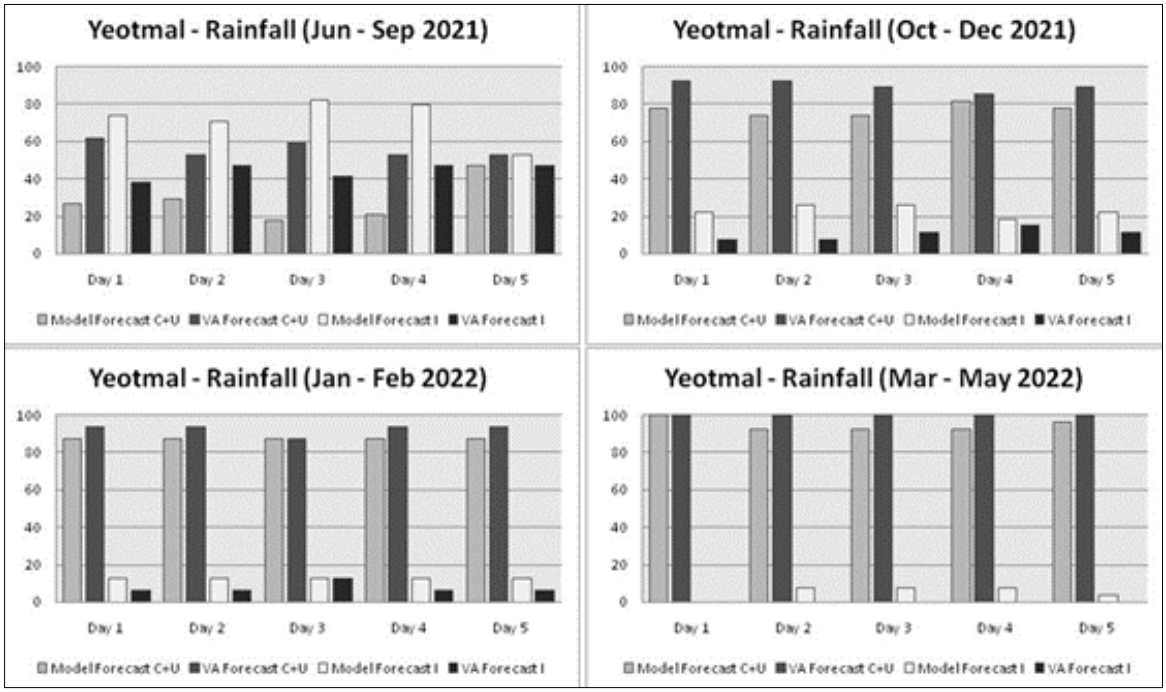

Fig 11: Qualitative accuracy correct+ usable (C+I) and Incorrect (I) for rainfall for Yeotmal

3.2 Verification Analysis for Maximum and Minimum temperatures

3.2.1 Verification of temperatures (Maximum and Minimum) for Akola

The maximum temperatures as seen from Figure-12 during the SW monsoon season model based forecasts showed better qualitative efficacy in days 2, 3 and 4. The value added forecast efficacy was marginally less in these days. However, for days 1 & 5, value added forecast efficacy was slightly better than the model based one. During winter season also, the model based forecasts showed better efficacy in days 4 & 5, and during the other 3 days, the value additions were at par or marginally better. During the Pre-Monsoon and Post-Monsoon seasons of the study period, the model based forecasts were qualitatively very effective (>80%) and the value additions did not make any large difference.

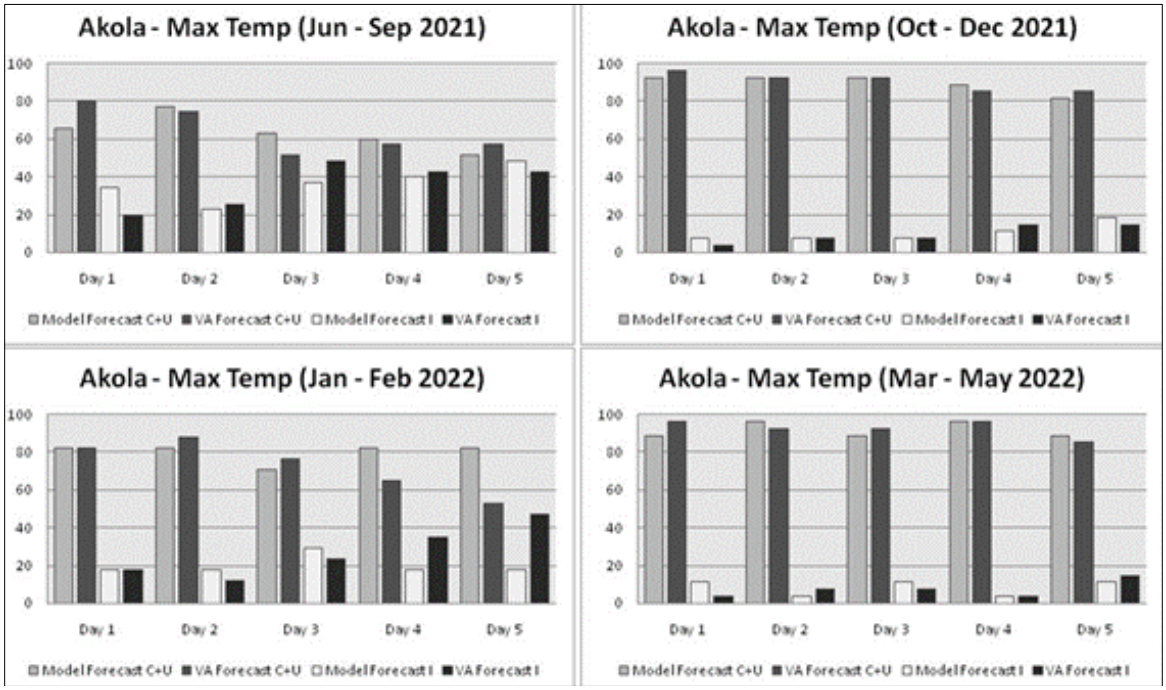

Fig 12: Qualitative accuracy correct +usable (C+I) and Incorrect (I) for maximum Temperature for Akola

The minimum temperatures as seen from Figure-13 show that for the SW Monsoon, Post-Monsoon and Pre-Monsoon seasons of the study period, the qualitative efficacy of the value added forecasts were much better than that of the model based forecasts. However, for day 5 of the post-monsoon season of the study period, the model based forecast was slightly better. During winter season of the study period, the model based forecasts were slightly better than the value added for days 2 & 5. However, for days 1, 3 & 5, the value added forecasts were significantly better.

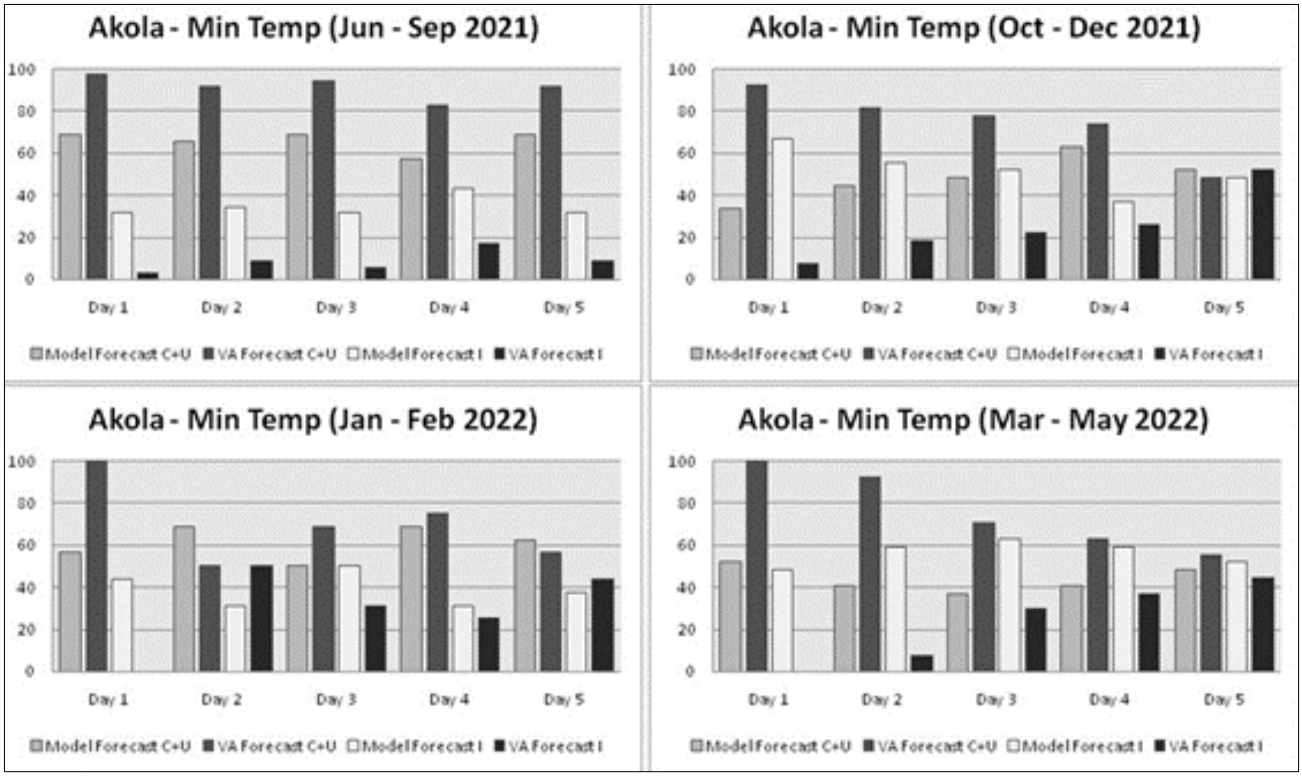

Fig 13: Qualitative accuracy correct +usable (C+I) and Incorrect (I) for minimum Temperature for Akola

.2.2 Verification of temperatures (Maximum and Minimum) for Amravati As seen from the Figure-14, the qualitative efficacy of the model based forecasts for maximum temperature were better for all the 5 forecasted days as compared to the value added forecasts during the Post-monsoon season of the study period. During the SW monsoon season, value added forecasts showed better efficacy for all the days. During the Winter season, day 2 and during the pre-monsoon season days 2 & 4 the model forecasts were better. For the rest of the days, value added forecasts exhibited better skills.

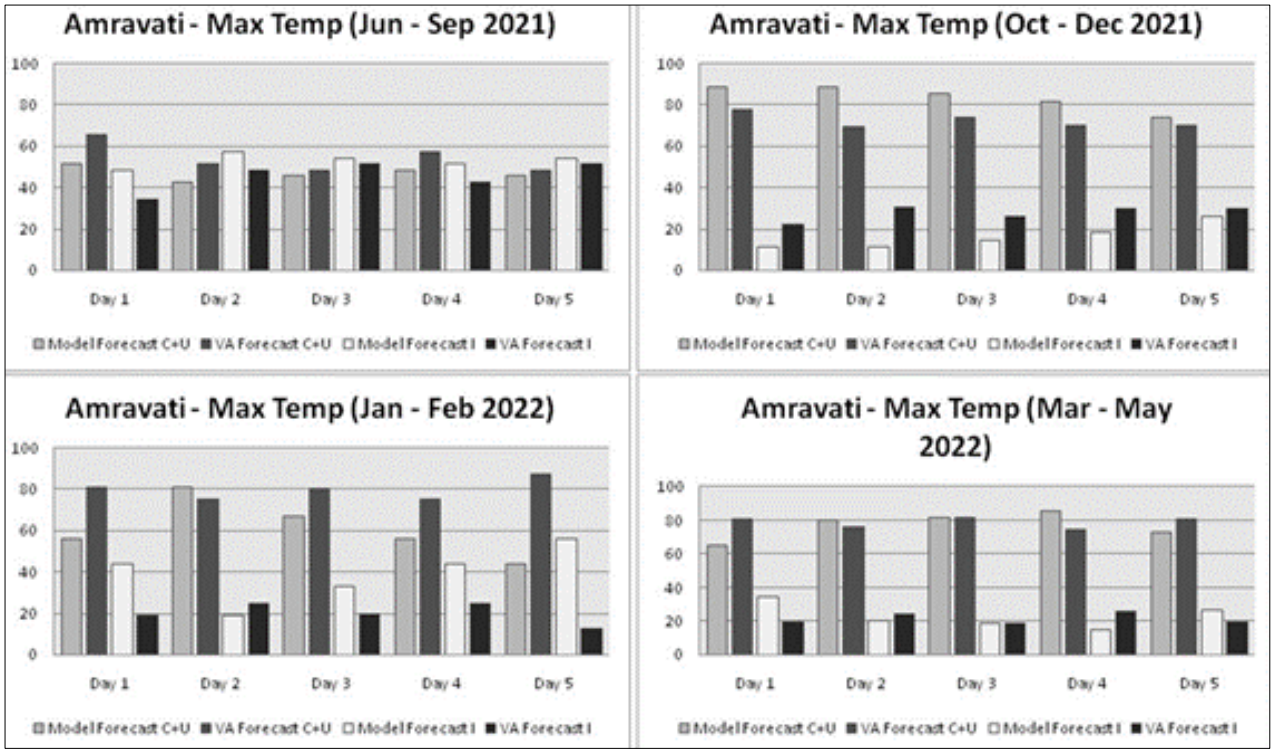

Fig 14: Qualitative accuracy correct+ usable (C+I) and Incorrect (I) for maximum Temperature for Amravati

As evident from Figure-15, the qualitative efficacy of the value added forecasts for minimum temperature were comparatively much better than that of the model based forecasts for all the 5 forecasted days during all the season.

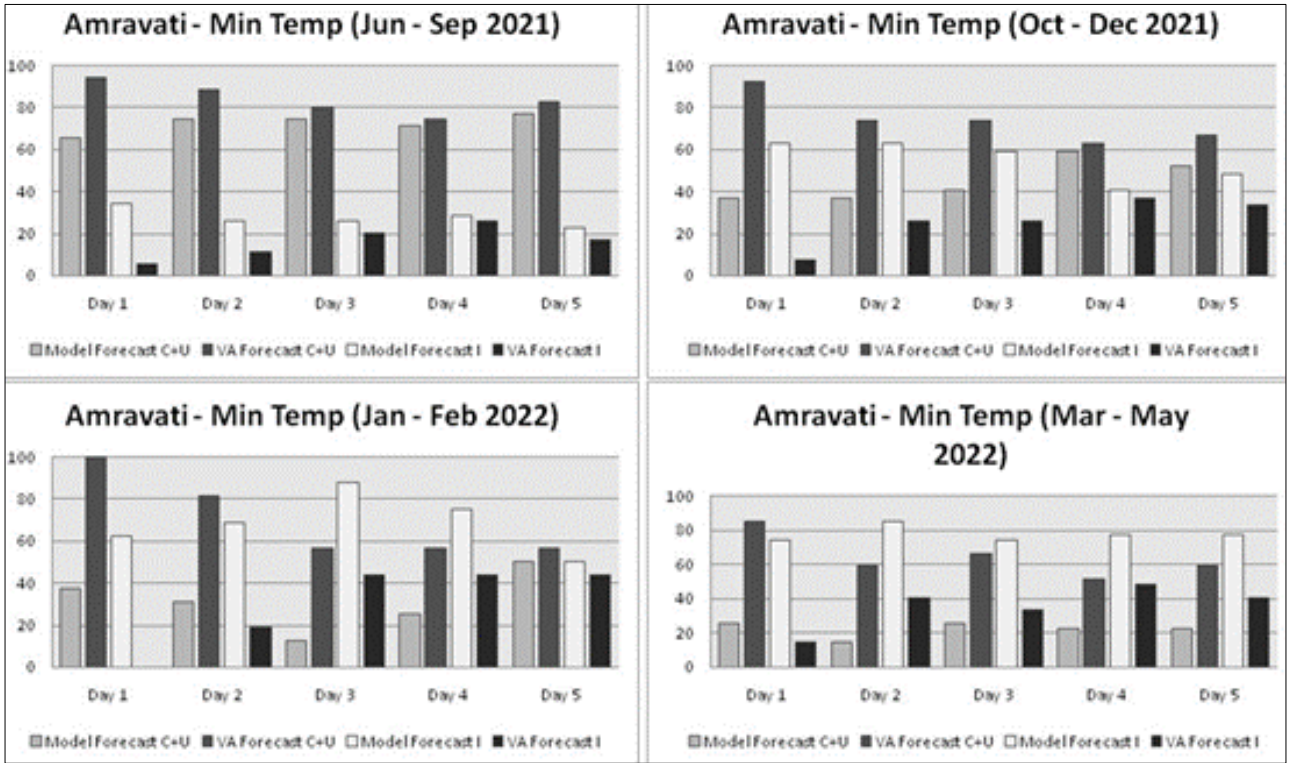

Fig 15: Qualitative accuracy correct+ usable (C+I) and Incorrect (I) for minimum Temperature for Amravati

3.2.3 Verification of temperatures (Maximum and Minimum) for Buldhana

It can be seen from the Figure-16 that the qualitative efficacy of the value added forecasts for maximum temperature were comparatively much better than that of the model based forecasts for all the 5 forecasted days during all the season.

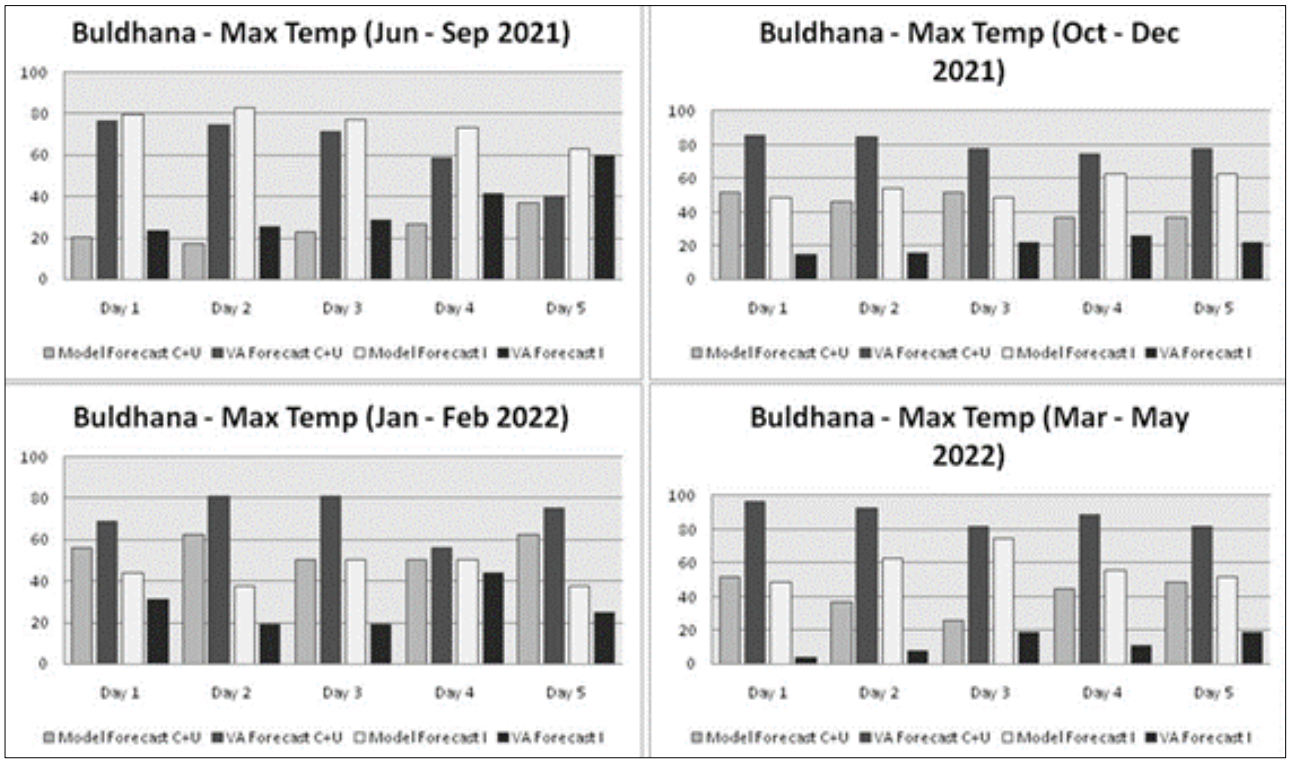

Fig 16: Qualitative accuracy correct+ usable (C+I) and Incorrect (I) For maximum Temperature for Buldhana

As seen from the Figure-17, the qualitative efficacy of the value added forecasts for minimum temperature were better for all the 5 forecasted days as compared to the model based forecasts during the Pre-monsoon season of the study period. During the SW monsoon and winter seasons, except day 2, value added forecasts showed better efficacy for all other days. During the post-monsoon season days 3, 4 & 5 the model forecasts were better.

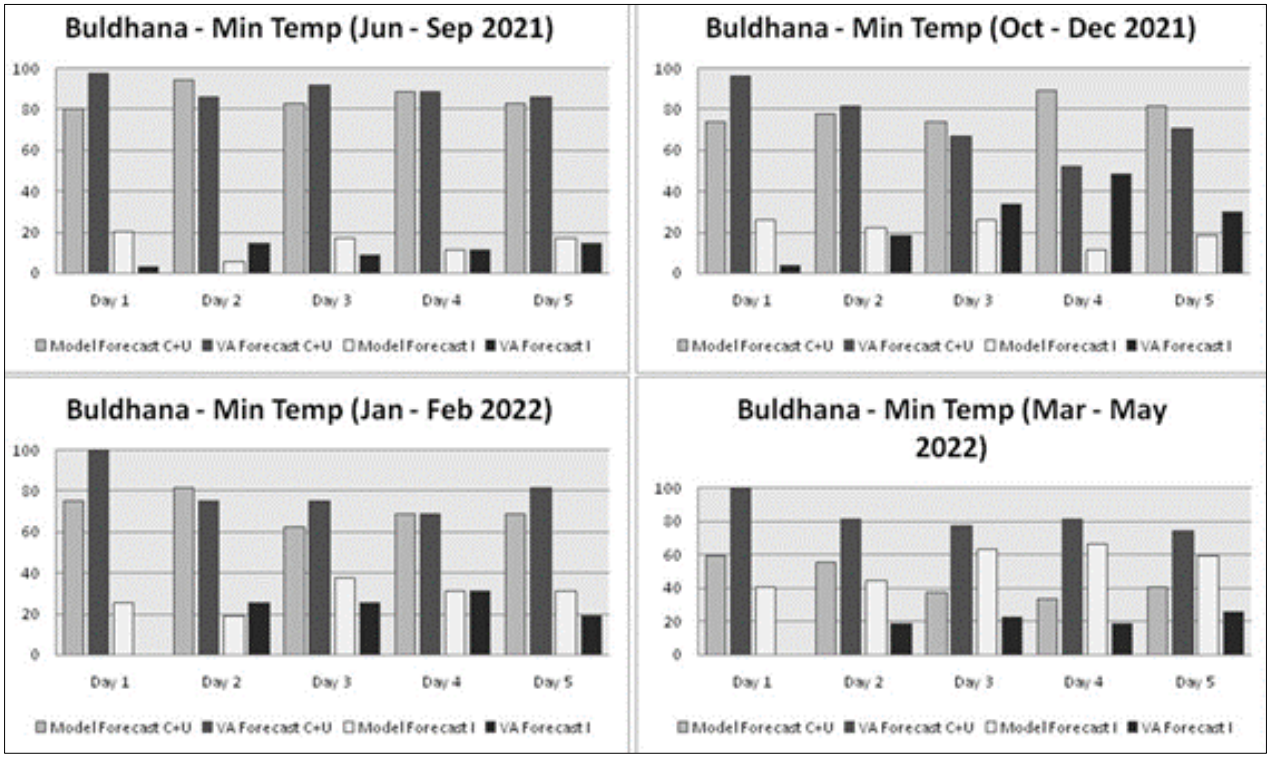

Fig 17: Qualitative accuracy correct+ usable (C+I) and Incorrect (I) For minimum Temperature for Buldhana

3.2.4 Verification of temperatures (Maximum and Minimum) for Chandrapur

It can be seen from the Figure-18 that the qualitative efficacy of the model based forecasts for maximum temperature were comparatively better or at par with that of the value added forecasts for all the 5 forecasted days during SW monsoon. During the other three seasons, the model based forecasts were qualitatively very effective (>80%) though the value added forecasts were slightly better.

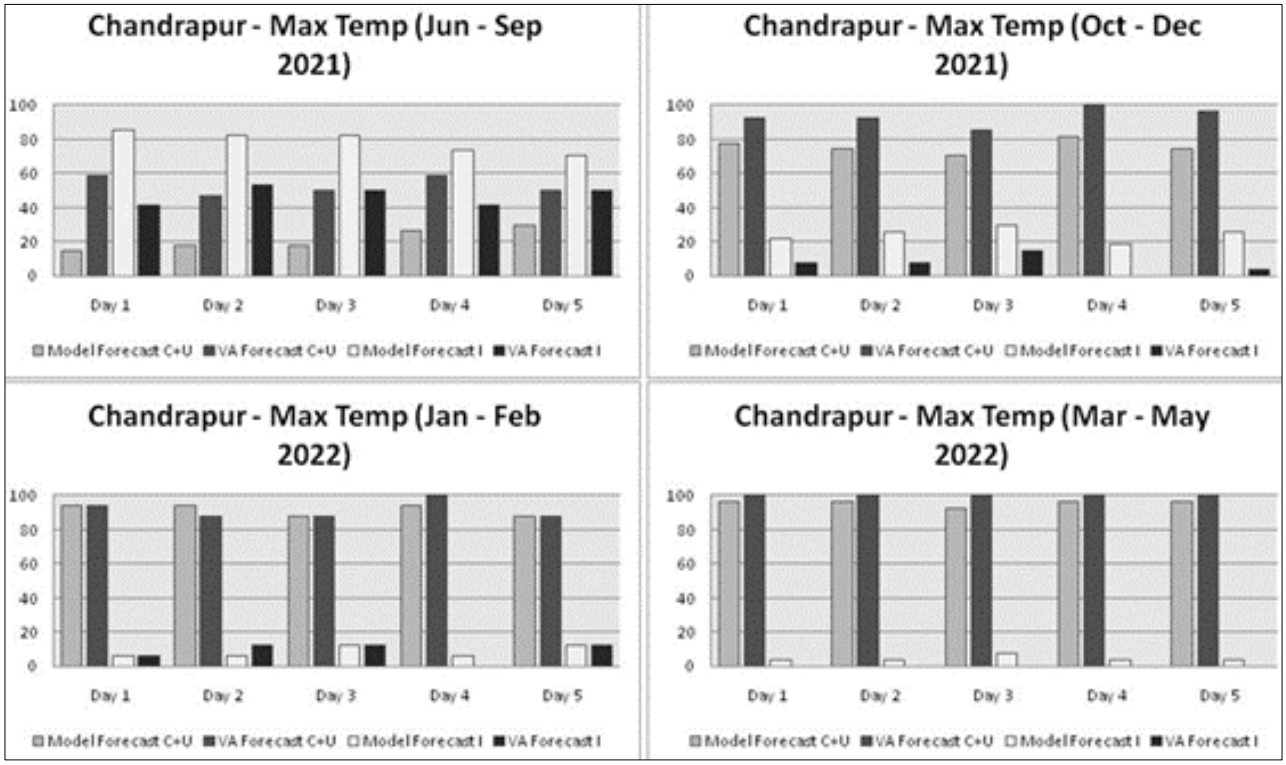

Fig 18: Qualitative accuracy correct+ usable (C+I) and Incorrect (I) For maximum Temperature for Chandrapur

As seen from the Figure-19 the qualitative efficacy of the value added forecasts for minimum temperature were comparatively much better than that of the model based forecasts for all the 5 forecasted days during SW monsoon, winter and pre-monsoon seasons of the study period. However, during post-monsoon season, the model based forecasts were better in days 2, 3, 4 & 5.

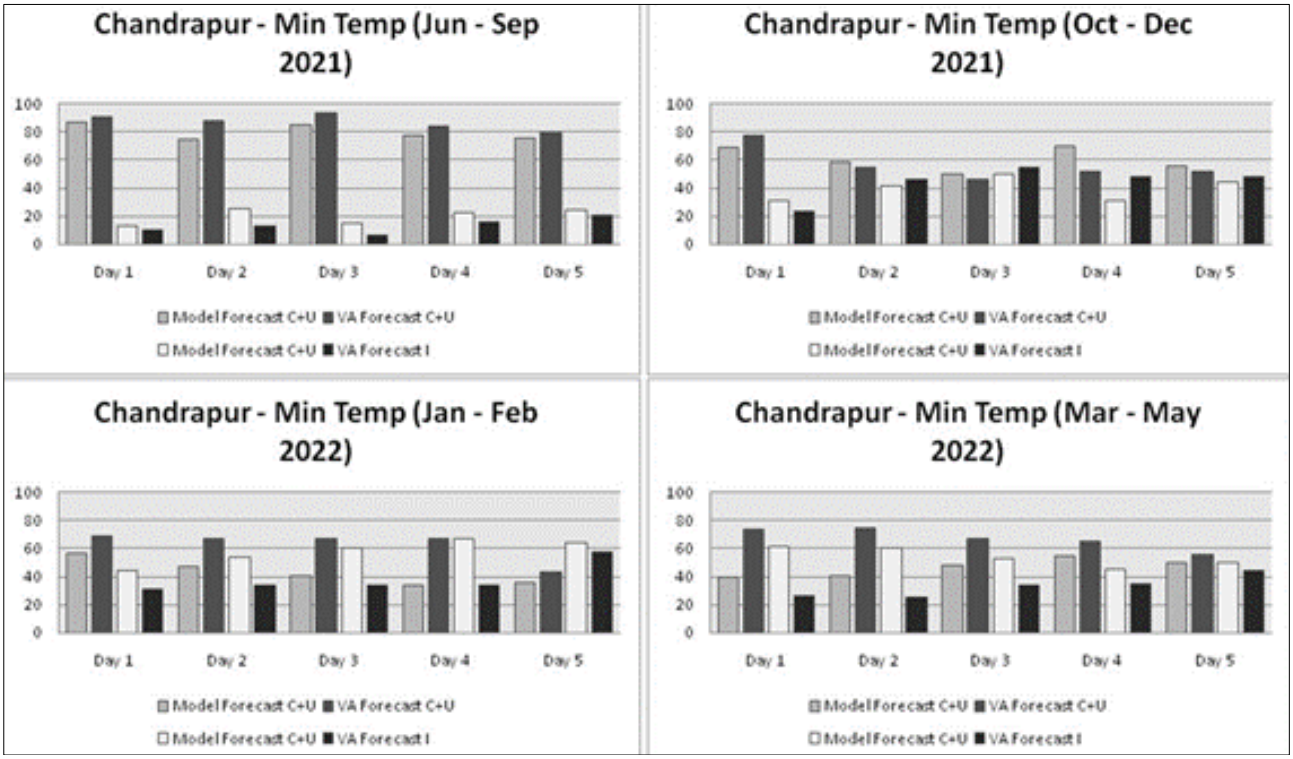

Fig 19: Qualitative accuracy correct + usable (C+I) and Incorrect (I) For minimum Temperature for Chandrapur

3.2.5 Verification of temperatures (Maximum and Minimum) for Gadchiroli

It can be seen from the Figure-20 that the qualitative efficacy of the value added forecasts for maximum temperature were comparatively much better than that of the model based forecasts for all the 5 forecasted days during SW monsoon, Post-monsoon and winter seasons of the study period. However, during pre-monsoon season, the model based forecasts were much better than the value added forecasts for all the 5 forecasted days.

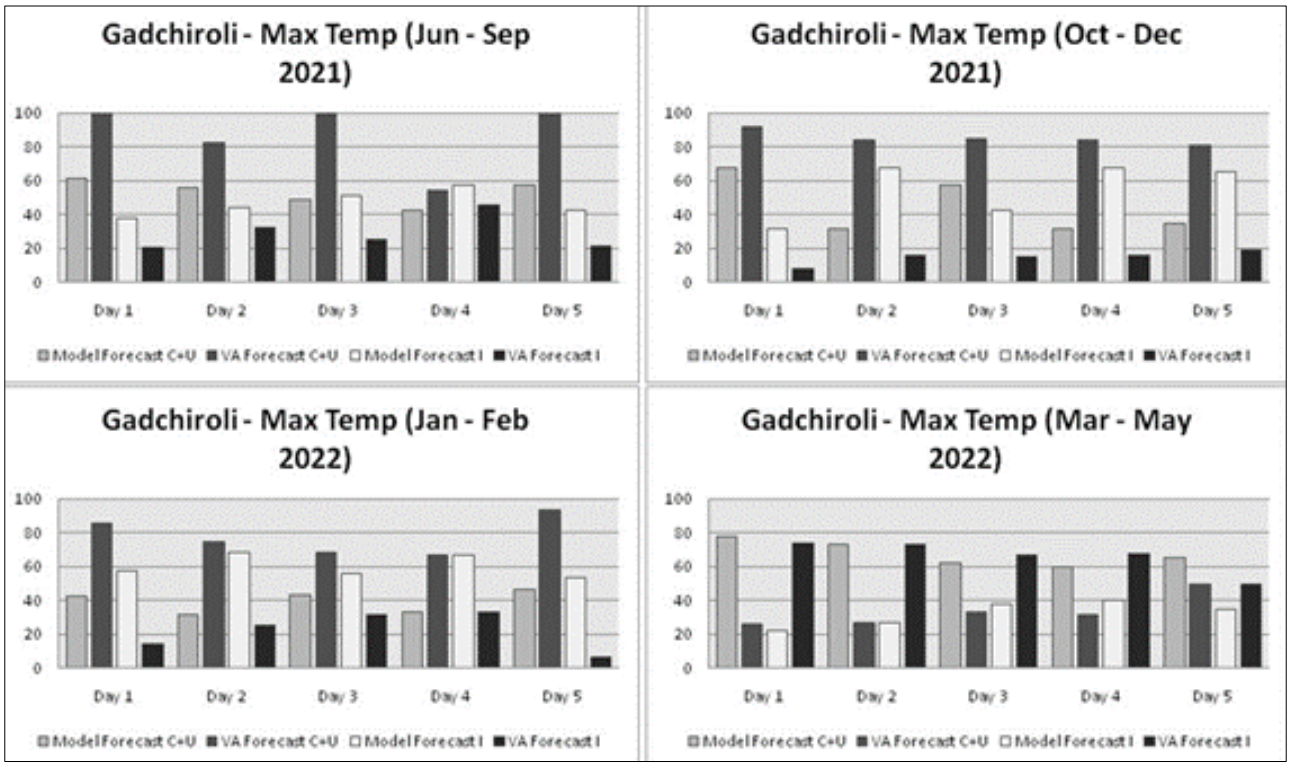

Fig 20: Qualitative accuracy correct+ usable (C+I) and Incorrect (I) For maximum Temperature for Gadhchiroli

As seen from the Figure-21 that the qualitative efficacy of the value added forecasts for minimum temperature were comparatively much better than that of the model based forecasts for all the 5 forecasted days during SW monsoon and post-monsoon seasons of the study period. However, during post-monsoon season, the model based forecasts were better in days 1, 2 & 5 and during the winter season the model based forecast was better in day 5.

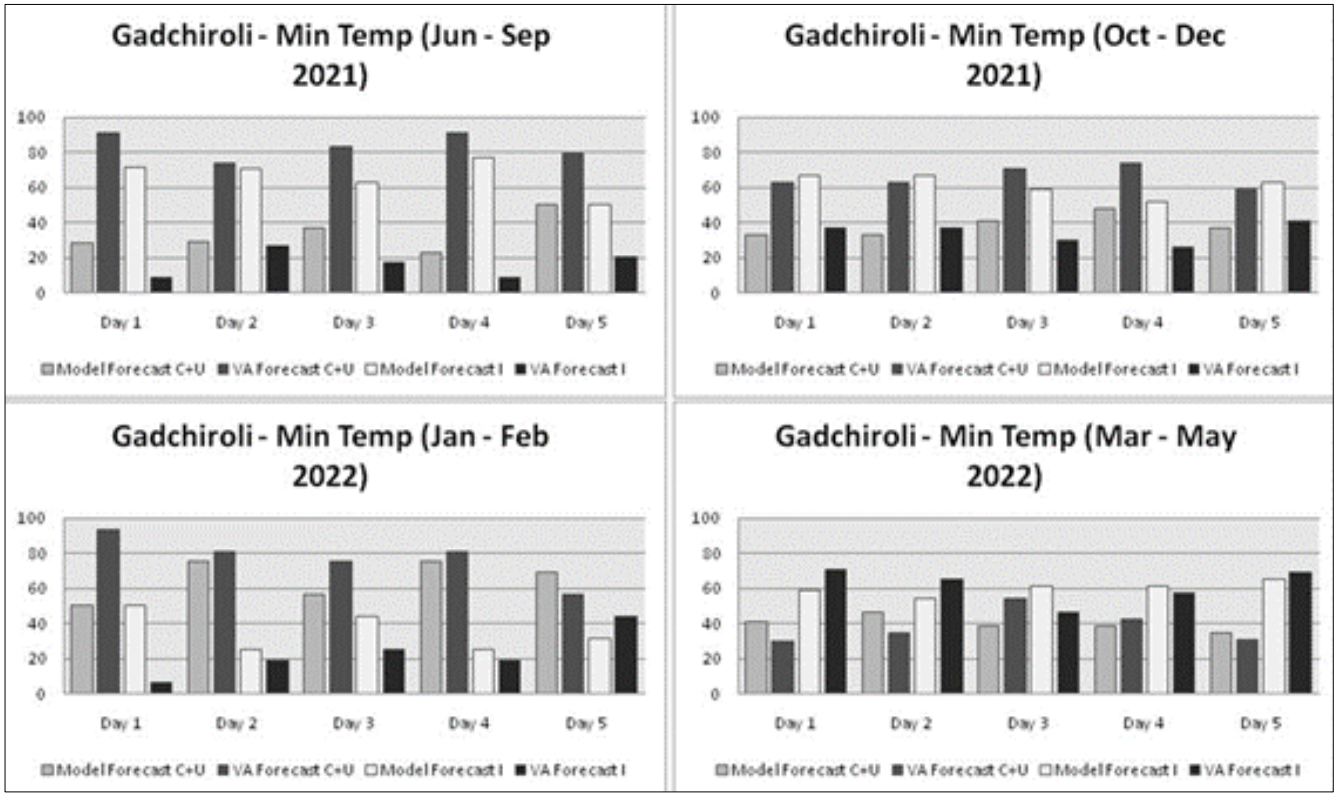

Fig 21: Qualitative accuracy correct+ usable (C+I) and Incorrect (I) For minimum Temperature for Gadhchiroli

3.2.6 Verification of temperatures (Maximum and Minimum) for Gondia

It can be seen from the Figure-22 that the qualitative efficacy of the value added forecasts for maximum temperature were comparatively better than that of the model based forecasts for all the 5 forecasted days for all the seasons.

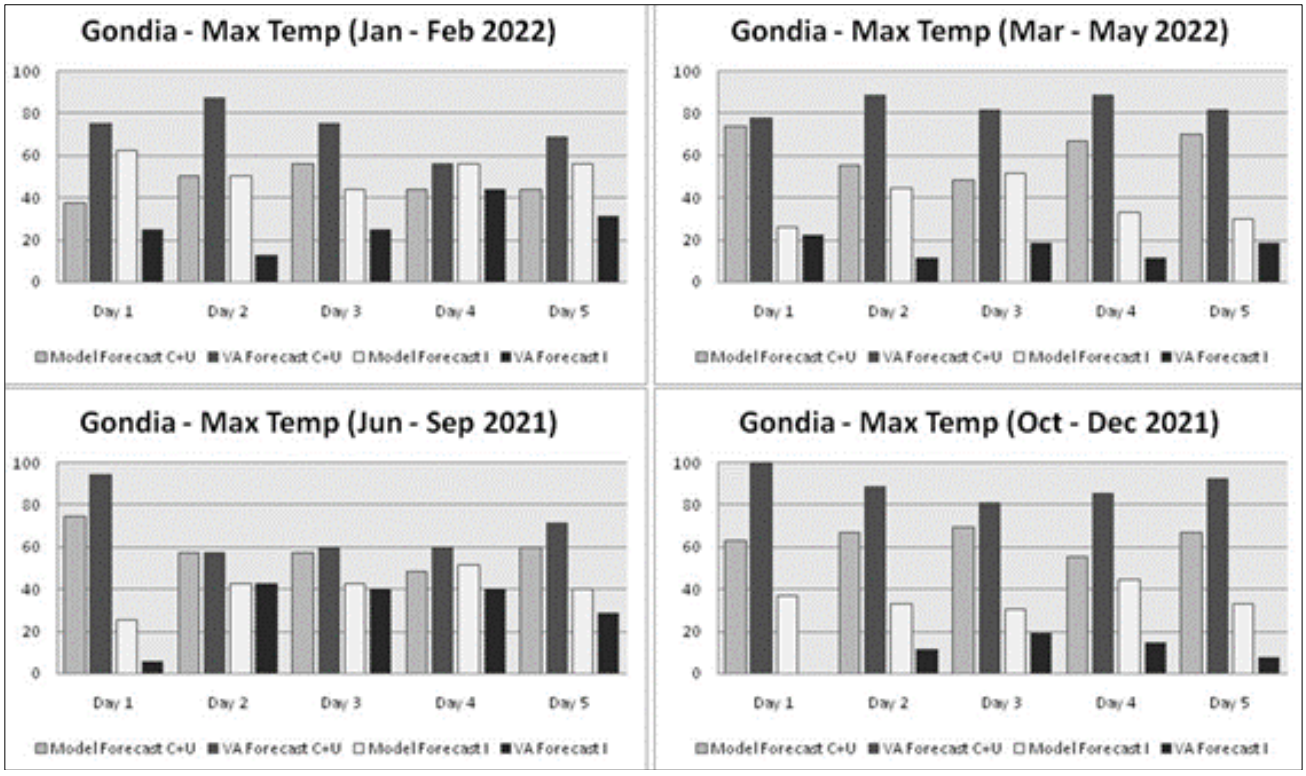

Fig 22: Qualitative accuracy correct+ usable (C+I) and Incorrect (I) For maximum Temperature for Gondia

As seen from the Figure-23 that the qualitative efficacy of the value added forecasts for minimum temperature were comparatively better than or at par with that of the model based forecasts for all the 5 forecasted days during all the seasons.

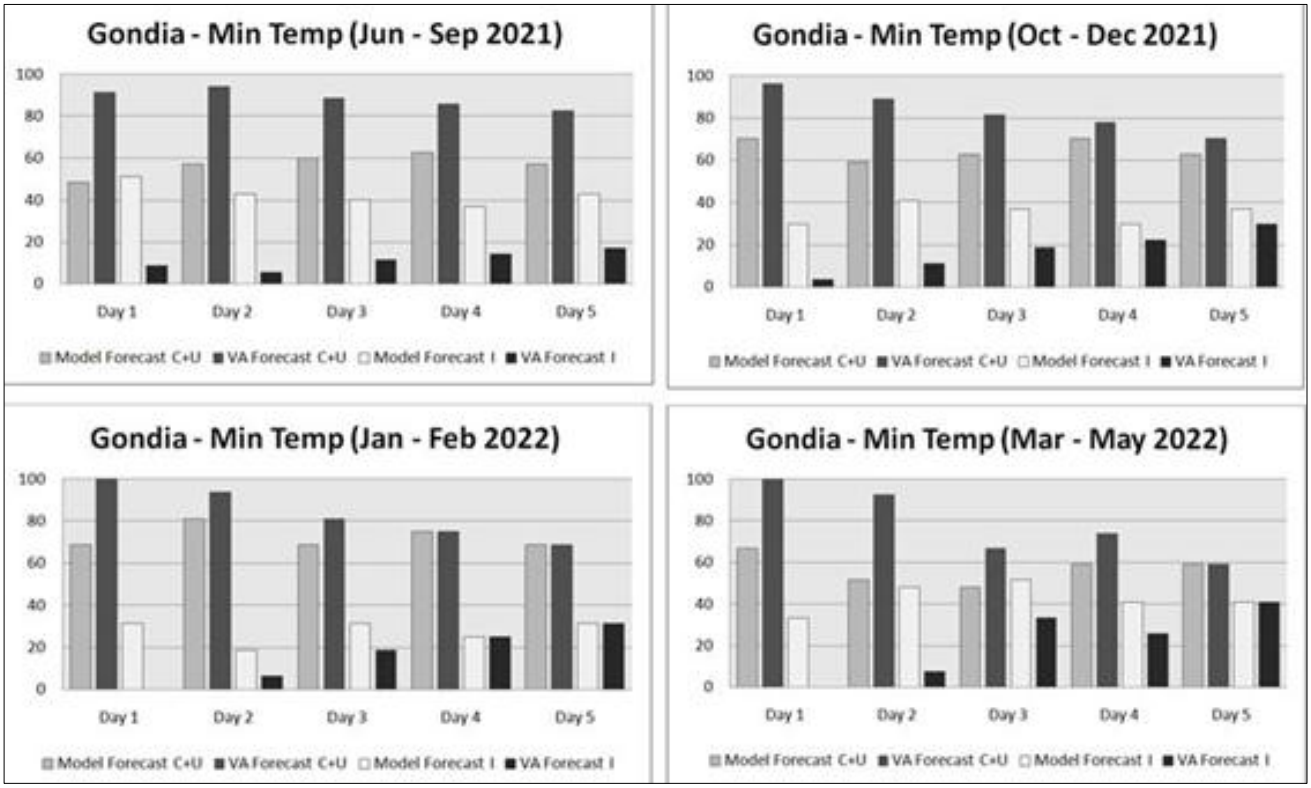

Fig 23: Qualitative accuracy correct+ usable (C+I) and Incorrect (I) For minimum Temperature for Gondia

3.2.7 Verification of temperatures (Maximum and Minimum) for Nagpur

It can be seen from the Figure-24 that the qualitative efficacy of the value added forecasts for maximum temperature were comparatively better or at par with that of the model based forecasts for all the forecasted days during all the season except for day 5 during the post-monsoon season.

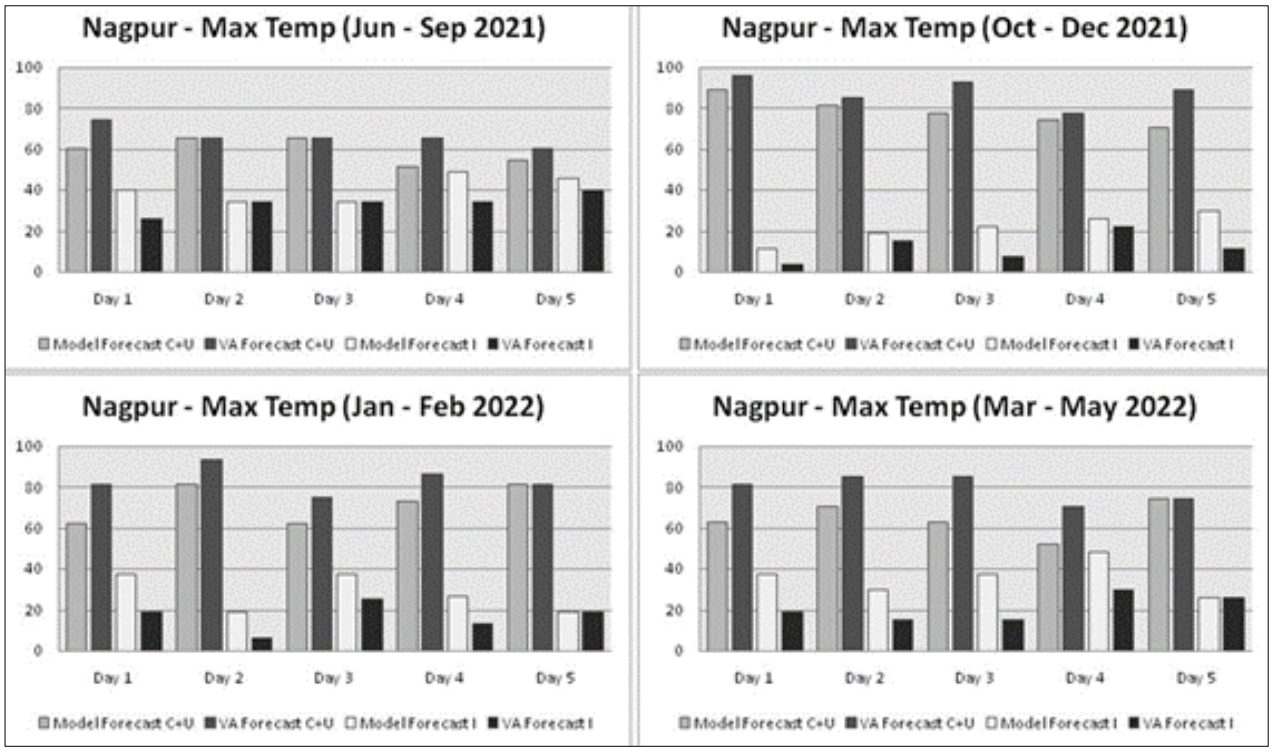

Fig 24: Qualitative accuracy correct +usable (C+I) and Incorrect (I) For maximum Temperature for Nagpur

As seen from the Figure-25, the qualitative efficacy of the value added forecasts for minimum temperature were comparatively much better than that of the model based forecasts for all the 5 forecasted days during all the season.

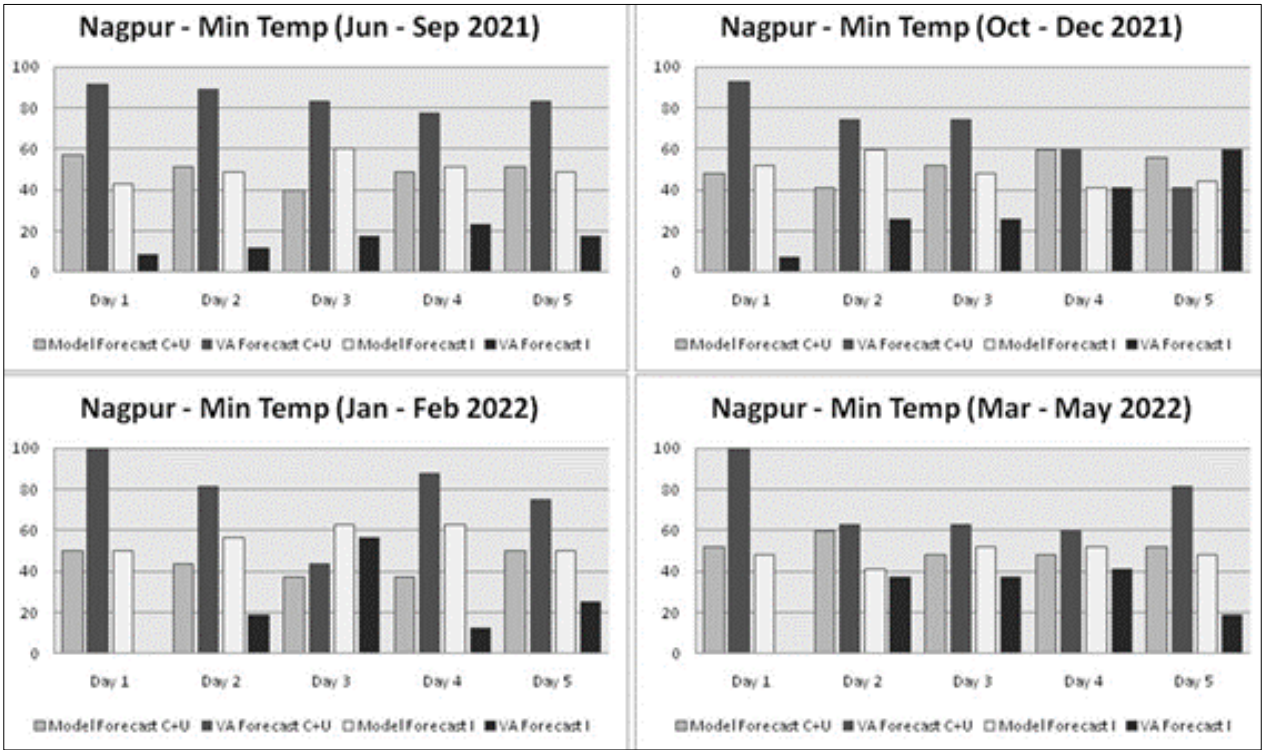

Fig 25: Qualitative accuracy correct +usable (C+I) and Incorrect (I) For minimum Temperature for Nagpur

3.2.8 Verification of temperatures (Maximum and Minimum) for Wardha

It can be seen from the Figure-26 that the qualitative efficacy of the value added forecasts for maximum temperature were comparatively better as compared to that of the model based forecasts for all the forecasted days during all the season except for day 2 during the SW-monsoon season.

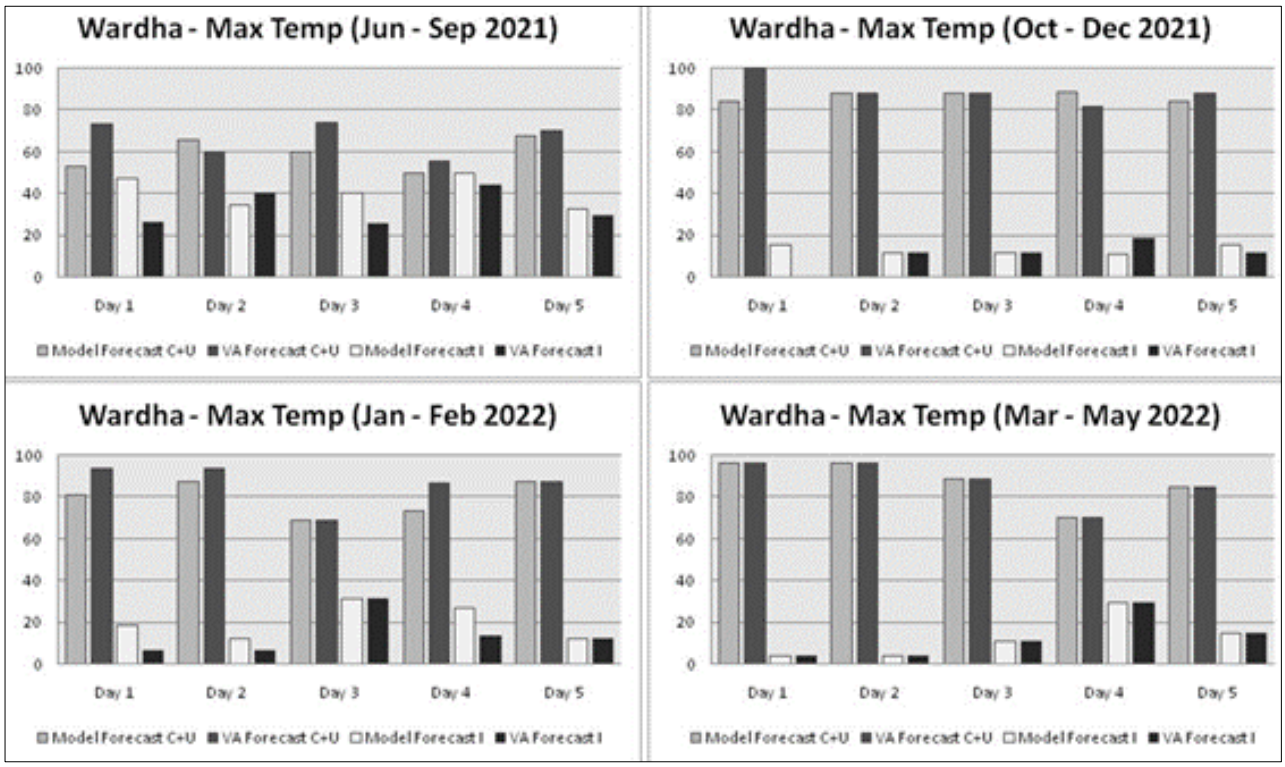

Fig 26: Qualitative accuracy correct +usable (C+I) and Incorrect (I) For maximum Temperature for Wardha

As seen from the Figure-27, the qualitative efficacy of the value added forecasts for minimum temperature were comparatively better as compared to that of the model based forecasts for all the forecasted days during all the season except for day 4 during the post-monsoon season.

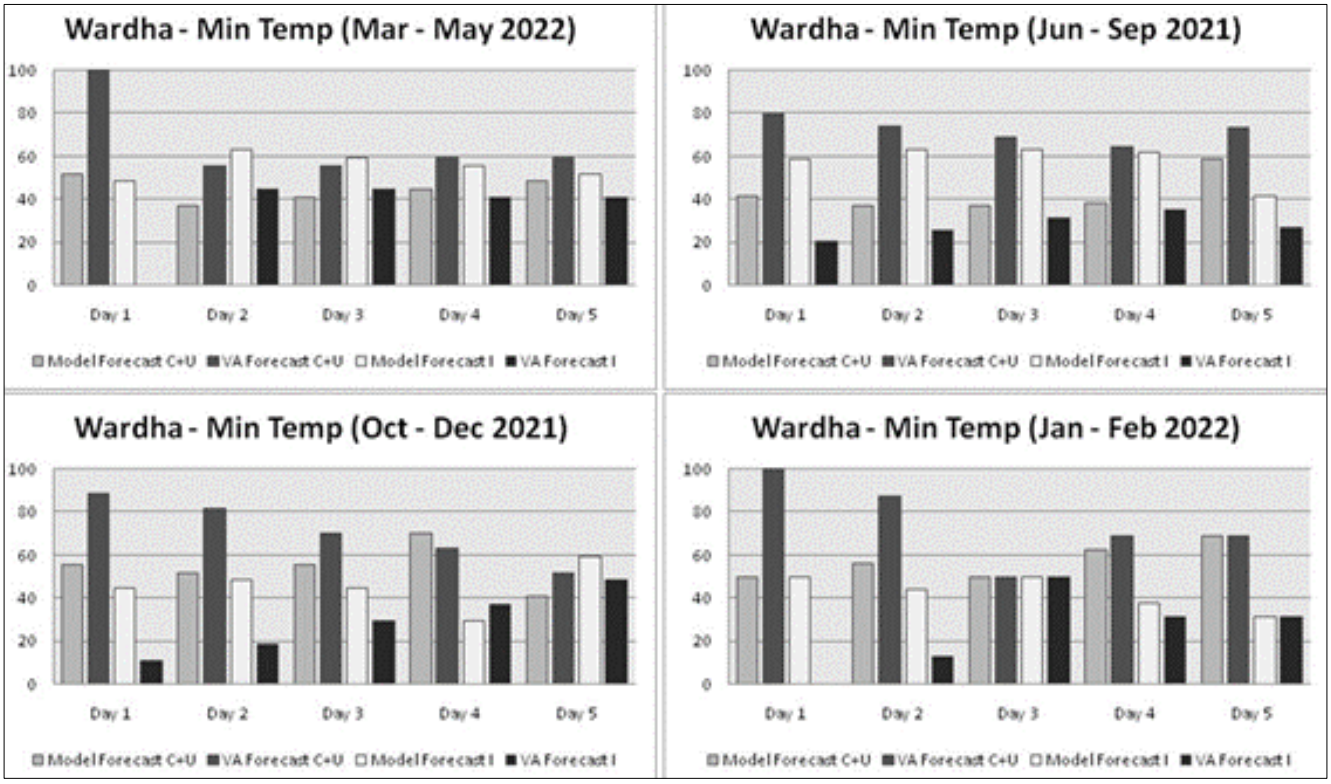

Fig 27: Qualitative accuracy correct + usable (C+I) and Incorrect (I) For minimum Temperature for Wardha

3.2.9 Verification of temperatures (Maximum and Minimum) for Washim

It can be seen from the Figure-28 that the qualitative efficacy of the value added forecasts for maximum temperature were comparatively much better than that of the model based forecasts for all the 5 forecasted days during all the season.

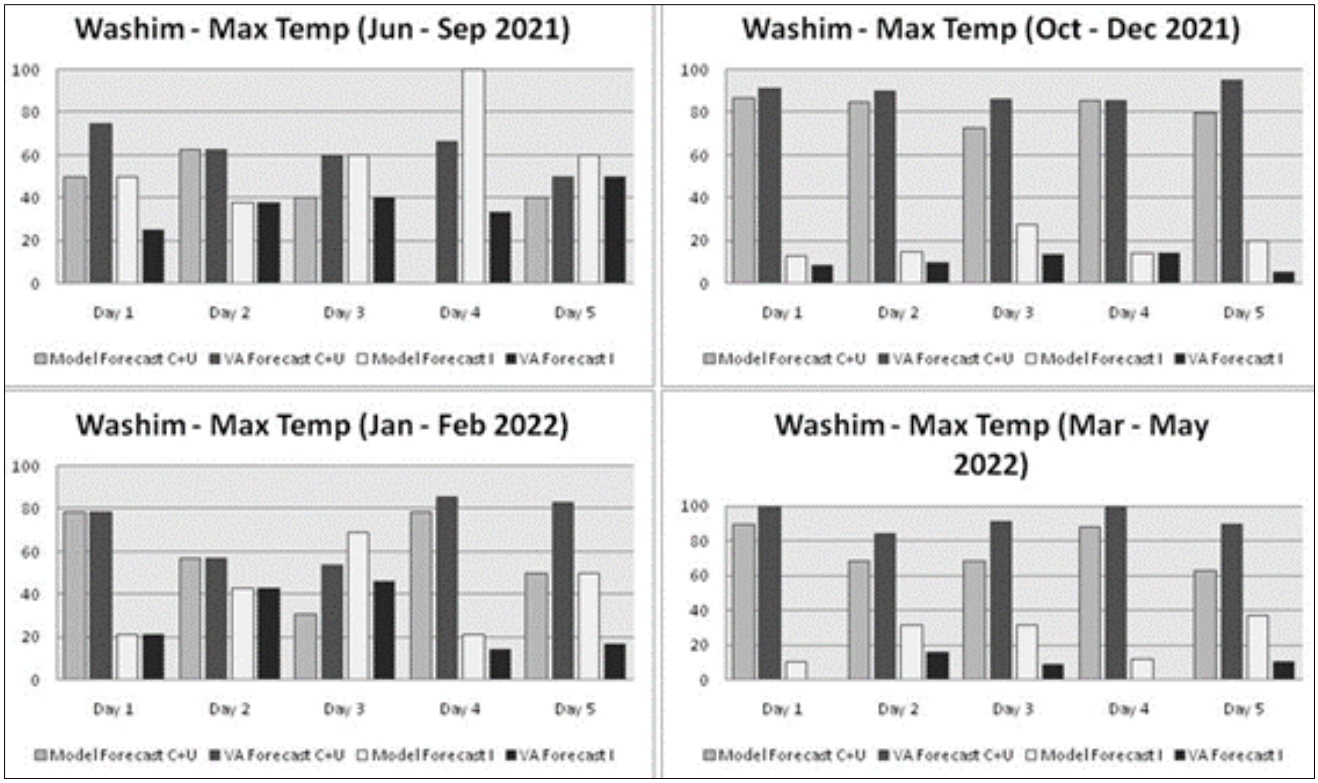

Fig 28: Qualitative accuracy correct+ usable (C+I) and Incorrect (I) For maximum Temperature for Washim

As seen from the Figure-29, the qualitative efficacy of the value added forecasts for minimum temperature were also comparatively much better than that of the model based forecasts for all the 5 forecasted days during all the season.

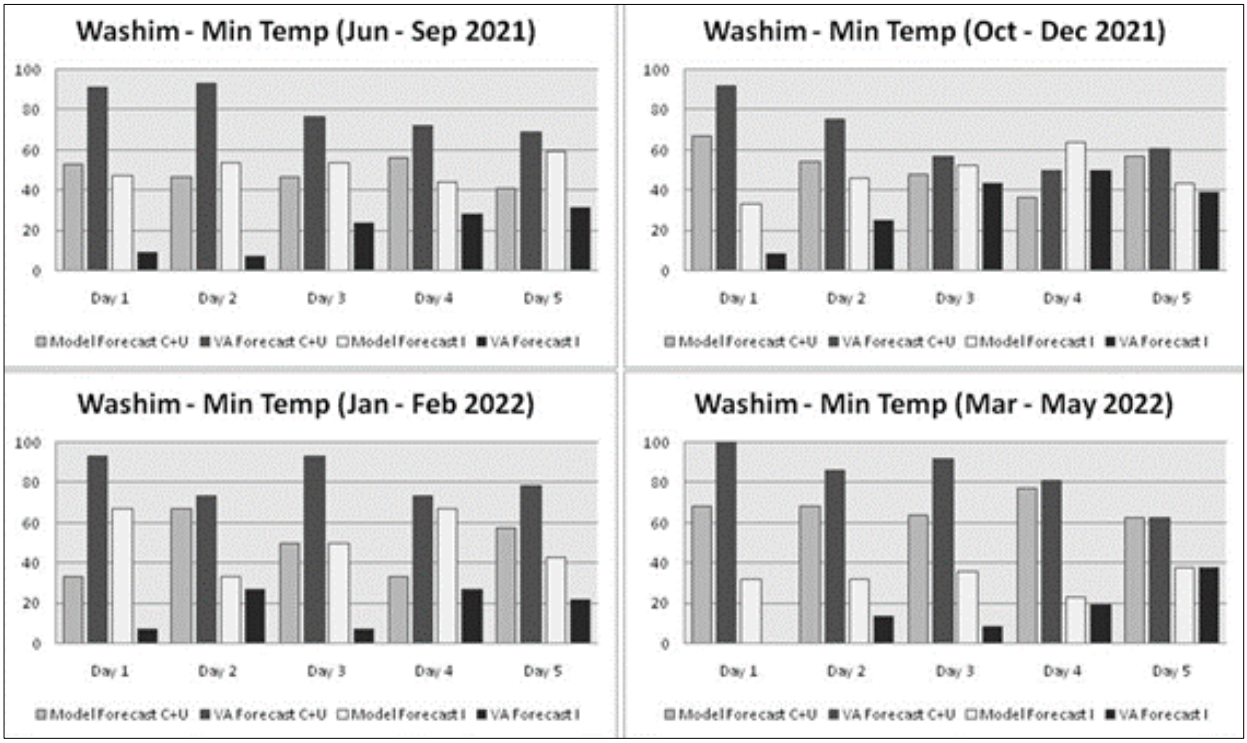

Fig 29: Qualitative accuracy correct + usable (C+I) and Incorrect (I) For minimum Temperature for Washim

3.2.9 Verification of temperatures (Maximum and Minimum) for Yeotmal

It can be seen from the Figure-30 that the qualitative efficacy of the value added forecasts for maximum temperature were comparatively much better than that of the model based forecasts for all the 5 forecasted days during SW monsoon, Post-monsoon and winter seasons of the study period. However, during pre-monsoon season, the model based forecasts were much better than the value added forecasts for all the 5 forecasted days.

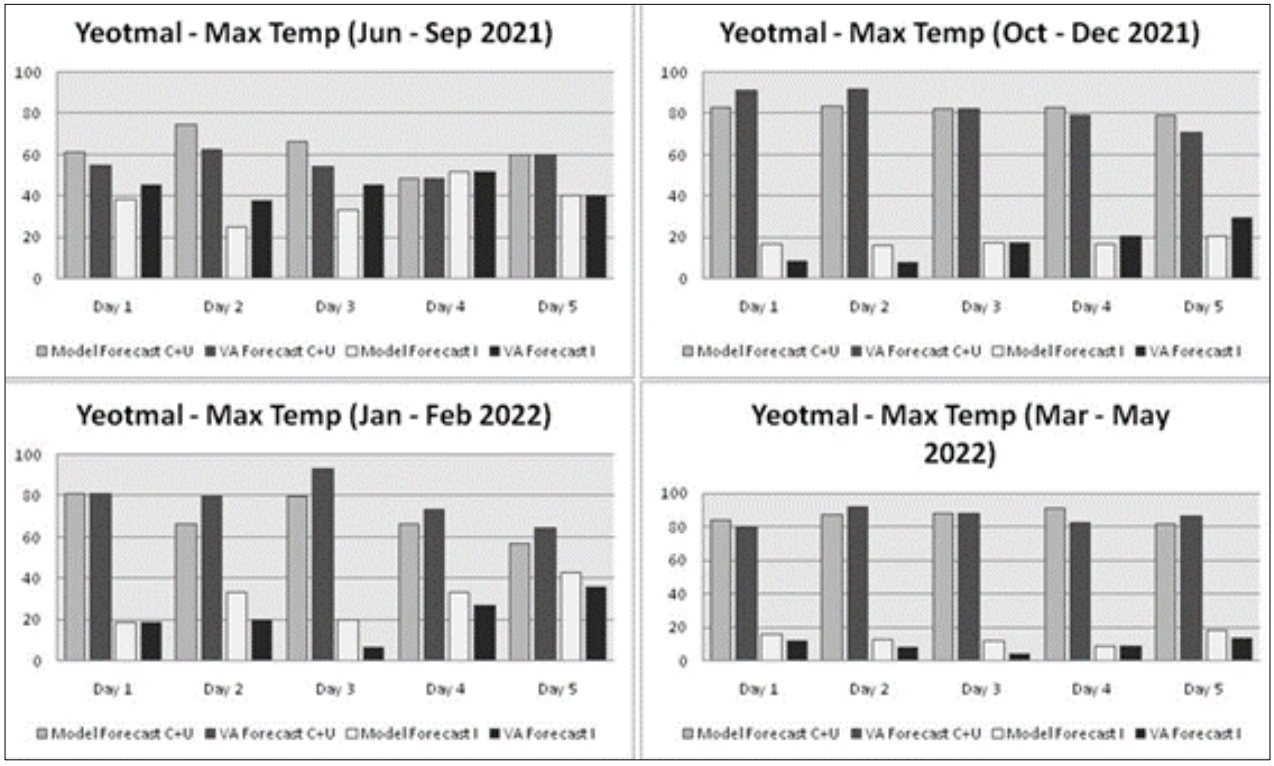

Fig 30: Qualitative accuracy correct + usable (C+I) and Incorrect (I) For maximum Temperature for Yavatmal

As seen from the Figure-31, the qualitative efficacy of the value added forecasts for minimum temperature were comparatively better as compared to that of the model based forecasts for all the forecasted days during all the season except for day 3 during the post-monsoon season.

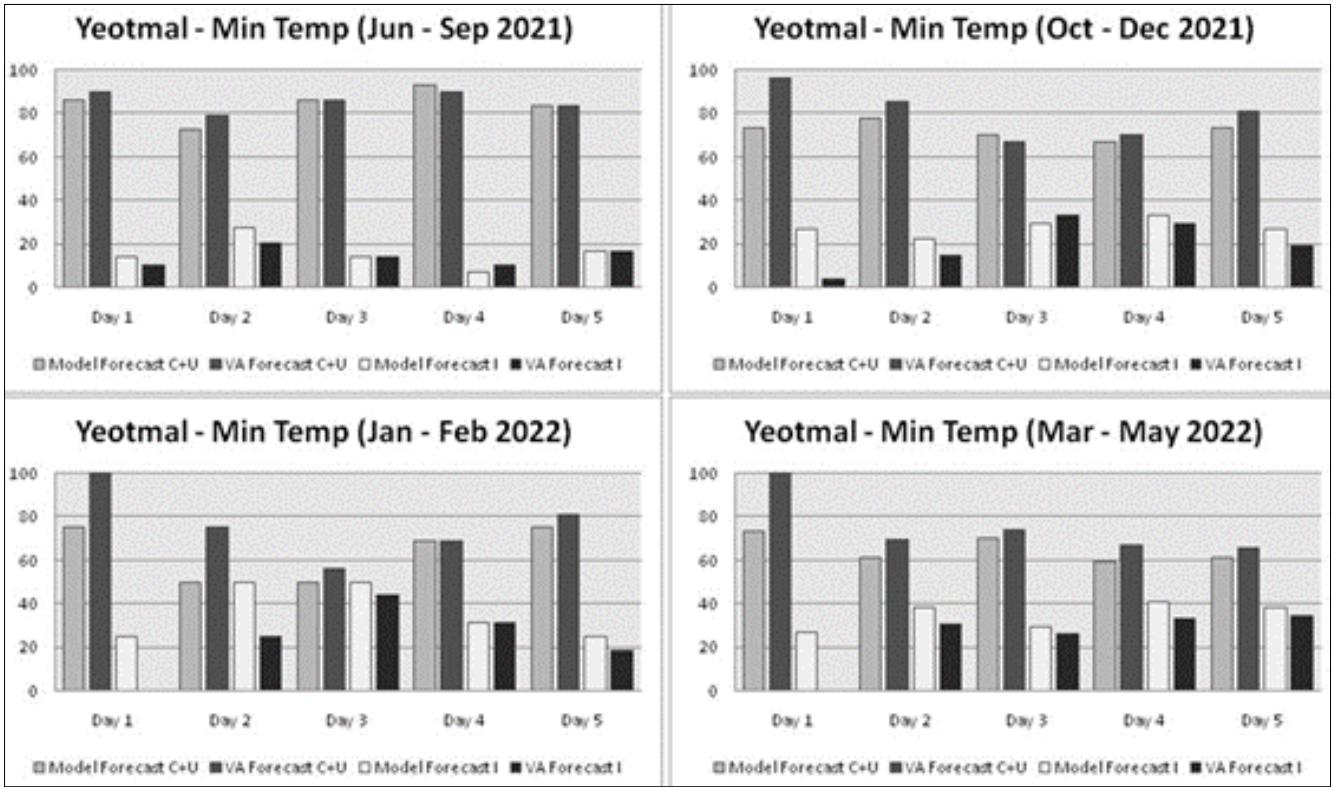

Fig 31: Qualitative accuracy correct +usable (C+I) and Incorrect (I) For minimum Temperature for Yavatmal

4. Summary and Conclusions

The results revealed that for rainfall, the value added forecast accuracy was much better than that of the model based forecast almost all the districts of Vidarbha for all the 5 forecasted days. However, both model and accuracy were mostly less than 50% during SW Monsoon season, the value added forecasts faring marginally better. For Maximum and Minimum temperatures, though the value added forecast accuracy was better than those of the model based forecasts for most of the districts in all the four seasons, the model based forecasts were better for few districts. Improvement in value added forecast accuracy during monsoon season will prove much more beneficial for the farming community to plan during various stages of crop growth, right from sowing till reaping.

5. Acknowledgements

The authors express their sincere thanks to Dr. Mrutyunjay Mohapatra, Director General of Meteorology, India Meteorological Department for his encouragement and support for carrying out this research work. The authors are also thankful to the India Meteorological Department, New Delhi for the timely uploading Model data on a daily basis.

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