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Research Article

Qualitative and Quantitative Analysis of Weather Forecast for Cauvery Delta Zone of Tamil Nadu

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Abstract: In India, agricultural production was principally based on weather parameters. The agro services based on weather parameters will be a useful practice for the farmers. In Tamil Nadu, Cauvery Delta Zone is a major agricultural production area and productivity depends on the climatic condition. This paper deals with the verification of the weather forecast for the Cauvery Delta Zone of Tamil Nadu. The Agromet Advisory Services were issued to Cauvery Delta Zone districts based on weather forecasts received from the India Meteorological Department and actual weather data recorded at the Agrometeorological observatory of Tamil Nadu Rice Research Institute, Aduthurai were analyzed to verify the validity and correctness of weather forecast during 2020. The forecast weather parameters were analyzed by qualitative and quantitative methods. The outcome of results showed that overall weather parameter predictions were better and effective during summer followed by winter season with higher values of probability success (87 & 82%), RMSE (3.5 & 3.9), ratio score (85 & 95%), and forecast correctness (70 & 61%). The rainfall forecast during monsoon and post-monsoon season were poor with probability success (58 & 46%), RMSE (7.6 & 8.1), ratio score (58 & 64%) and forecast correctness (37 & 25%). Nagapattinam district showed better performance in overall weather forecast over Cauvery Delta Zone districts. Hence in the future, further refinement is needed in rainfall forecast especially during the monsoon and post-monsoon seasons of the Cauvery Delta Zone.

Keywords: Medium range weather forecast, Verification, Ratio score, RMSE, Usability?

Introduction

Agriculture in India is the gamble of the monsoon. Weather plays important role in reaping the success or failure of agriculture production. Its minor variability creates a great impact on the growth and development of crops at every stage and also it influences the population of pests and diseases which eventually affect crop yield. The weather aberrations like early onset or late onset of monsoon, dry spell, flood, hailstorm, heavy wind, heat, or cold wave would affect the crop production. In those situations, taking proper crop management practices in advance will save the crop from yield losses. For that, an accurate weather forecast has to be given for the farmer's community. The weather forecast has been provided by the India Meteorological Division (IMD) since the mid-seventies to the state meteorological centers. Despite one day in advance forecasts, farmers cannot take contingency measures. Farmers needed medium-range weather forecasts to carry out precautionary measures and agricultural operations. In view of that, IMD, Ministry of Earth Sciences (MoES) under the scheme "Gramin Krishi Mausam Seva" (GKMS) issues medium range weather forecast at the district level in the country. With that information, farmers can use available natural resources effectively and minimize the yield loss due to unfavorable weather conditions (Venkataraman, 2004). The weather based agro meteorological service reduced the cost of cultivation by 2 to 5 percent (Rathore and Parvinder, 2008). In Tamil Nadu, Tamil Nadu Rice Research Institute is the AMFU unit for the Cauvery Delta Zone districts and which providing weather based Agromet-advisories for the farming community of the Cauvery Delta Zone (CDZ). This paper deals with the study of validation of weather forecasting done for seven districts of the Cauvery Delta Zone during 2020 by the TRRI, Aduthurai.

Materials and methods

Agro - Meteorological Field Unit (AMFU) for Cauvery Delta Zone of Tamil Nadu is Tamil Nadu Rice Research Institute located in Thanjavur district, Tamil Nadu state. Located at 11o N latitude 79.3o E longitude with an altitude of 19.4 m above Mean Sea Level. Tamil Nadu Rice Research Institute is the. The zone comprises of eight districts viz. Thanjavur, Thiruvarur, Trichy, Nagapattinam, Cuddalore, Karur, Perambalur, and Ariyalur. The seasonal forecast was verified against actual observations of various weather parameters by following different methods depending upon the type of variables namely continuous or categorical. In the qualitative analysis, continuous weather parameters like maximum temperature, minimum temperature, rainfall, cloud cover, relative humidity, and wind speed were verified by Root Mean Square Error (RMSE) and simple success probability method (Singh et al. 1999). Simple success probability has been carried out purely on a `yes' or `no' basis by examining whether the event occurred or not as per the forecast. The RMSE values will be a sign of the degree of error in the forecast. Higher values indicate more error between observed and forecast values. For the qualitative analysis of the categorical weather element like rainfall, the skill score test has been used based on the contingency table (Wilks, 1995). The skill score test includes Ratio Score (RS), Critical Success Index (CSI), Heidke Skill Score (HS), and Hanssen and Kuipers Scores (HK) measures. The contingency table was prepared by comparing the predicted and observed rainfall data. The table indicates four categories of conditions viz., no rain - no rain, no rain - rain, rain - no rain, and rain- rain. The quantitative verification has been worked out using a usability analysis method based on the critical values of error for weather parameters.

Results and discussion

Qualitative analysis

Simple Success Probability

Study of success probability of weather parameters for Cauvery Delta districts during 2020 was provided in Table1.

Rainfall

The simple success probability analysis of rainfall forecast indicated that all districts registered above 80 % success rate during winter and summer. During South West Monsoon and North East Monsoon, all the districts registered 30-60 % success only. Mostly higher success was observed during winter followed by summer, SEM, and NEM. However, Nagapattinam district performed better with an average 79% success rate over other districts at different seasons.

Maximum Temperature

Maximum temperature probability analysis indicated that a higher success percentage (>80 percent) was registered during all seasons in different districts of the Cauvery Delta Zone. All the districts registered maximum success of 87 percent on average during the summer season. And then Nagapattinam district recorded maximum success percentage (87%) over other districts.

Minimum Temperature

In the minimum temperature, all the districts scored a higher success percentage of more than 90% in summer, SWM, and NEM season. During the winter season, only Thanjavur and Thiruvarur district registered higher success percentages. On the other hand, Thanjavur and Thiruvarur district recorded the highest success rate on average during different seasons.

Relative Humidity

Probability analysis on relative humidity indicated that a higher success percentage (> 90 percent) was noticed in all districts in all different seasons of 2020. The highest value of success was noticed during summer and NEM followed by winter and SWM seasons. All the districts of the Cauvery Delta Zone showed a 98% of average success rate during all the seasons respectively.

Cloud Cover

The overall success percentage of cloud cover was higher in all the seasons (>80 percent) except during SWM in all the districts. During SWM season also, except Thanjavur, Thiruvarur all the districts registered >80% of success rate. This is due to a higher percentage of an incorrect forecast. While interior districts viz., Trichy, Karur, Perambalur, Ariyalur districts registered the highest success value during all the seasons over coastal districts.

Wind Speed

The results on probability analysis of wind speed showed that the overall success percentage was only below 70 percent in all the districts during all the seasons of 2020. Where summer seasons registered the highest and winter season registered the lowest success rate in different districts respectively. Nagapattinam is the only district registered overall higher success percentage (69%) during all the seasons.

On the whole, the probability success values showed that the weather parameters prediction for Cauvery Delta Zone districts was excellent during summer followed by winter, NEM, and SWM season. Likewise, similar findings were reported by Kumar and Chand (2010).

Root Mean Square

Root Mean Square Error Analysis (RMSE) of weather parameters for Cauvery delta zone Table 2 indicated that rainfall and maximum temperature recorded lower value of RMSE during summer (2.0 and 1.7) and winter season (1.7 and 1.8). On the other hand during the NEM season, that recorded higher RMSE values (8.1 and 2.0) in different districts of the Cauvery Delta Zone. In the case of minimum temperature, a lower RMSE value of 1.3 was noticed during SWM, whereas a higher RMSE value was recorded during the winter season (2.2). The cloud cover recorded minimum RMSE value during the summer season as compared to other seasons in Cauvery Delta Zone districts. In general, RH and wind speed registered higher values of RMSE than other weather parameters. Minimum RMSE values in RH (7.2) and wind speed (6.2) was observed during NEM in all the districts. While during SWM season, maximum RMSE values of RH (11.4) and wind speed (7.3) was noticed. Like Kothiyal et al. (2017) findings, the overall values of RMSE show that the predictability of weather parameters was better during summer followed by the winter season, and the Thiruvarur district registered the least forecast error in average during all seasons among different districts of Cauvery Delta Zone.

Skill Score

The different scores for evaluating rainfall forecast were presented Table 3. The Ratio Score (RS) indicated the number of the correct forecast to the total forecasts. Among the four seasons during the winter season, RS was recorded higher (95%) in different districts of the Cauvery Delta Zone. Followed by summer, recorded the highest overall RS value of 85%. Then SWM registered the least RS values (58%) than other seasons at different districts. And going further, Nagapattinam district recorded the highest RS value (82%) over other districts. The Critical Success Index (CSI) indicated the relative forecasting accuracy and number of hits or correct events. Higher values of CSI were noticed during NEM (0.56) followed by SWM (0.39) than other seasons in all the districts. Thanjavur district (0.46) registered the highest CSI values than other districts. While lower values of CSI were recorded during the summer season (0.12) and Ariyalur district (0.19) respectively. The Heidke Skill Score (HS) indicated all correct forecasts and Hanssen and Kuipers Scores (HK) specify the economic saving over climatology due to perfect forecast. Likewise CSI values, a similar trend was observed in HS score also. This is due to the more number of hit values during SWM, NWM seasons, and correct negative values during winter, summer seasons (Mishra, 2006). Whereas, the HK score registered maximum value during the summer season (0.28) and Nagapattinam district in Cauvery Delta Zone respectively. Chauhan et al. (2008) observed a similar trend in the annual rainfall forecast.

Quantitative analysis

Usability Analysis

In Table 4, usability analysis of various weather parameters during 2020 is presented.

Rainfall

Concerning rainfall, a higher percentage of the correct forecast was observed during the winter season (95%) followed by summer (83%) over different districts which was mainly due to more number of no rain - no rain situation. The correct forecast was recorded minimum during NEM, 2020 in all the CDZ districts over other seasons indicates the seasonal variability. Regarding useful forecast, SWM and NEM showed higher percent values. Among the different districts, Nagapattinam district registered better rainfall correct forecast.

Maximum Temperature

The percent of correctness for Maximum temperature was ranged between 60 to 70% among different seasons of Cauvery Delta Zone districts. Among the different districts, a higher percent of correct forecasts (71%) were registered in Nagapattinam district and among different seasons, winter & summer had better predictions than others in all the districts.

Minimum Temperature

The minimum temperature correct forecast was higher (>70%) during SWM & NEM seasons. Though the percent of correctness for minimum temperature is lower (<60%) during the winter season, the percent of usefulness is higher among different seasons in Cauvery Delta Zone districts. Among the different districts, Thiruvarur district showed better predictions with a higher percent of correctness in minimum temperature.

Relative Humidity

The percent of correctness for relative humidity forecast was ranged between 59 to 86% among different seasons of Cauvery Delta Zone districts. All the districts registered >70% of correctness during different seasons except SWM. Whereas the percent of usefulness is found higher with SWM.

Cloud Cover

The value of cloud cover percent of correctness was ranged between 51 to 69% during different seasons of the Cauvery Delta Zone. All the seasons except SWM were registered better cloud cover predictions with a higher percent of correctness and usefulness. On the other hand, all the districts except Thanjavur, Thiruvarur, and Nagapattinam showed accurate cloud cover forecast with the least percent of incorrectness.

Wind Speed

The prediction for wind speed was less accurate with a higher percent of incorrectness (30-50%) during all the seasons in different districts of the Cauvery Delta Zone. The percent of correctness was < 40% irrespective of seasons in Cauvery Delta Zone districts. However, summer and NEM season registered a higher percent of correctness among the different seasons.

As an outcome higher value of correctness was registered for all parameters except cloud cover and wind speed however higher values of the usable forecast were registered for cloud cover and wind speed in different districts of the Cauvery Delta Zone. Weather forecast reliability in the mid hill region of Himachal Pradesh (Rana et al. 2005) and eastern Uttar Pradesh (Tripathi et al. 2008) also observed similar findings.

Conclusion

The information discussed in this paper for the AMFU unit of CDZ revealed that the weather parameters viz., temperature, rainfall, relative humidity, cloud cover, wind speed were validated with the available procedures such as qualitative and quantitative verification of AAS concluded that weather prediction was quite accurate during summer and winter seasons in Cauvery Delta Zone districts. Which will help the farmers in doing pre-sowing operations regarding kharif crop and taking summer crops effectively. The Critical Success Index and Heidke Skill Score showed that predicting the rain events during monsoon and the post-monsoon season was good enough which will help farmers for scheduling irrigation, pest and disease management, appropriate field operations. But precision is required in predicting the amount of rainfall during rainy days. There is also a precision need in wind speed prediction.

Table 1. Simple success probability analysis of weather parameters in Cauvery Delta Zone during 2020

District/ Season	Rainfall		Tmax		Tmin		RH		Cloud cover		Wind Speed		Total cases
	Success	Failure	Success	Failure	Success	Failure	Success	Failure	Success	Failure	Success	Failure	
Thanjavur													
Winter	56	3	48	11	55	4	57	2	54	5	35	24	59
Summer	86	6	86	6	92	0	92	0	87	5	75	17	92
SWM	66	56	96	26	112	10	117	5	58	64	49	73	122
NEM	35	57	70	22	80	12	89	3	74	16	56	36	92
Thiruvarur													
Winter	57	2	48	11	59	0	57	2	57	2	35	24	59
Summer	87	5	86	6	92	0	92	0	87	5	75	17	92
SWM	75	47	95	27	112	10	117	5	59	62	49	73	122
NEM	27	65	76	16	81	11	89	3	72	20	56	36	92
Nagapattinam													
Winter	55	4	57	2	36	23	56	3	44	15	42	17	59
Summer	86	6	79	13	83	9	89	3	72	20	60	32	92
SWM	84	38	93	29	101	21	111	11	96	26	84	36	122
NEM	54	38	80	12	81	11	92	0	72	20	65	26	92
Trichy													
Winter	54	5	48	11	44	15	58	0	54	5	21	38	59
Summer	63	29	77	15	79	13	91	1	78	13	60	32	92
SWM	57	65	101	21	116	6	113	9	107	15	79	43	122
NEM	40	53	74	18	88	4	92	0	88	4	66	26	92

Karur													
Winter	57	2	46	13	40	19	58	0	50	9	21	38	59
Summer	75	17	76	16	79	13	91	1	79	13	60	32	92
SWM	78	44	102	20	116	6	113	9	107	15	79	43	122
NEM	49	43	73	19	83	9	92	0	90	2	66	26	92
Perambalur													
Winter	56	3	48	11	45	14	58	0	54	5	21	38	59
Summer	84	8	77	15	79	13	91	1	79	13	60	32	92
SWM	67	55	101	21	116	6	113	9	107	15	79	43	122
NEM	49	43	76	16	89	3	92	0	88	4	66	26	92
Ariyalur													
Winter	58	1	48	11	44	15	58	0	54	5	21	38	59
Summer	89	3	80	12	77	15	91	1	79	13	60	32	92
SWM	70	52	101	21	116	6	113	9	114	15	79	43	122
NEM	42	51	75	17	89	3	92	0	88	4	66	26	92

Table 2. Root Mean Square Error of weather parameters for Cauvery Delta Zone during 2020

Season	Rainfall	Maximum Temperature	Minimum temperature	Cloud cover	Relative humidity	Wind speed
Thanjavur						
Winter	0.6	1.9	1.9	2.1	8.7	7
Summer	1.2	1.4	0.7	1.4	7.9	6.5
SWM	6.2	2.1	1.2	3.1	9.1	8.1
NEM	7.0	2.7	1.7	2.2	5.9	9.3
Thiruvarur						
Winter	0.8	1.7	1.2	1.6	6.9	6.8
Summer	1.4	1.5	0.7	1.4	7.9	6.5
SWM	6.8	2.1	1.2	3.0	9.1	8.2
NEM	8.7	1.9	1.6	2.3	7.4	6.2
Nagapattinam						
Winter	0.8	1.3	2.5	2.3	8.2	6.3
Summer	1.7	1.6	1.5	2.1	7.5	7.9
SWM	8.1	2.0	1.8	2.0	9.6	5.6
l276NEM	12.7	1.6	1.6	2.0	7.5	5.9
Trichy						
Winter	1.1	1.9	2.4	1.6	9.3	9.1
Summer	2.8	1.8	1.7	1.6	8.2	6.0
SWM	5.7	1.8	1.2	1.6	13	7.2
NEM	9.7	1.8	1.2	1.4	7	5.5
Karur						
Winter	0.7	2.1	2.5	1.8	8.7	8.4
Summer	2.1	1.8	1.7	1.6	8.2	6.0
SWM	5.5	1.8	1.2	1.6	13.1	7.3
NEM	4.9	2.1	1.2	1.3	8.2	5.4
Perambalur						
Winter	0.7	1.9	2.3	1.7	9.5	9.3
Summer	4.0	1.8	1.7	1.6	8.2	6.0
SWM	8.6	1.8	1.2	1.6	13	7.2
NEM	6.0	1.8	1.1	1.4	7.1	5.5

Ariyalur						
Winter	0.4	1.9	2.4	1.6	9.3	9.1
Summer	0.9	1.8	1.8	1.6	8.2	6.0
SWM	12.5	1.8	1.2	1.6	13	7.2
NEM	7.9	1.8	1.1	1.4	7.0	5.6

Table 3. Skill score analysis of rainfall in Cauvery Delta Zone during 2020

District	Contingency table				Skill score			
	YY(a)	YN(b)	NY(c)	NN(d)	RS	CSI	HSS	HK
Thanjavur								
Winter	2	1	1	55	97	0.50	0.65	0.65
Summer	2	10	2	78	87	0.14	0.20	0.39
SWM	54	32	13	23	63	0.55	0.23	0.22
NEM	54	22	6	10	70	0.66	0.24	0.21
Nagapattinam								
Winter	1	2	1	55	95	0.25	0.37	0.46
Summer	1	4	1	86	95	0.17	0.26	0.46
SWM	47	10	32	33	66	0.44	0.32	0.36
NEM	13	7	20	52	71	0.66	0.30	0.28
Tiruvarur								
Winter	1	2	2	54	93	0.20	0.30	0.30
Summer	0	8	6	78	85	0.00	-0.08	-0.09
SWM	43	31	10	38	66	0.51	0.35	0.36
NEM	56	18	7	11	73	0.69	0.30	0.27
Karur								
Winter	0	2	0	57	97	0.00	0.00	-1.00
Summer	6	13	7	66	78	0.23	0.25	0.30
SWM	20	43	17	42	51	0.25	0.03	0.03
NEM	33	30	8	21	59	0.46	0.21	0.22
Perambalur								
Winter	0	3	0	56	95	0.00	0.00	-1.00
Summer	2	6	3	81	90	0.18	0.26	0.33
SWM	21	36	16	49	57	0.29	0.12	0.14
NEM	33	31	8	19	57	0.46	0.18	0.18
Trichy								
Winter	0	5	1	53	90	0.00	-0.03	-0.09
Summer	4	30	0	58	67	0.12	0.14	0.66
SWM	33	62	3	24	47	0.34	0.13	0.20
NEM	41	35	5	11	57	0.51	0.13	0.13
Ariyalur								
Winter	0	1	0	58	98	0.00	0.00	-1.00
Summer	0	8	1	83	90	0.00	-0.02	-0.09
SWM	26	44	11	41	55	0.32	0.15	0.19
NEM	30	33	4	25	60	0.45	0.27	0.31

Table 4. Usability analysis of weather parameters in Cauvery Delta Zone during 2020

District/ Season	Rainfall			Tmax			Tmin			RH			Cloud cover			Wind Speed			Total
	C	U	IC	C	U	IC	C	U	IC	C	U	IC	C	U	IC	C	U	IC	
Thanjavur																			
Winter	56	0	3	42	6	11	36	19	4	51	6	2	21	33	5	10	25	24	59
Summer	78	8	6	64	22	6	88	4	0	82	10	0	71	16	5	28	47	17	92
SWM	34	32	56	68	28	26	107	5	10	92	25	5	23	35	64	7	42	73	122
NEM	14	21	57	47	23	22	64	16	12	69	20	3	22	52	16	35	21	36	92
Thiruvarur																			
Winter	57	0	2	43	5	11	43	16	0	51	6	2	24	33	2	10	25	24	59
Summer	79	8	5	61	25	6	88	4	0	82	10	0	71	16	5	28	47	17	92
SWM	4	35	47	67	28	27	107	5	10	92	25	5	26	33	62	7	42	73	122
NEM	13	14	65	53	23	16	66	15	11	69	20	3	22	50	20	35	21	36	92
Nagapattinam																			
Winter	55	0	4	44	13	2	27	9	23	51	5	3	32	12	15	20	22	17	59
Summer	86	0	6	68	11	13	66	17	9	78	11	3	39	33	20	41	19	32	92
SWM	54	30	38	70	23	29	78	23	21	93	18	11	65	31	26	52	32	36	122
NEM	24	30	38	70	10	12	60	21	11	78	14	0	47	25	20	37	28	26	92
Trichy																			
Winter	53	1	5	40	8	11	29	15	15	40	18	0	35	19	5	12	9	38	59
Summer	57	6	29	55	22	15	64	15	13	78	13	1	66	12	13	38	22	32	92
SWM	27	30	65	81	20	21	102	14	6	57	56	9	75	32	15	44	35	43	122
NEM	17	23	53	56	18	18	78	10	4	82	10	0	64	24	4	41	25	26	92
Karur																			
Winter	57	0	2	37	9	13	30	10	19	40	18	0	32	18	9	12	9	38	59
Summer	68	7	17	55	21	16	63	16	13	78	13	1	66	13	13	38	22	32	92
SWM	50	28	44	80	22	20	101	15	6	57	56	9	75	32	15	44	35	43	122
NEM	23	26	43	54	19	19	73	10	9	82	10	0	66	24	2	41	25	26	92
Perambalur																			
Winter	56	0	3	41	7	11	30	15	14	40	18	0	32	22	5	12	9	38	59
Summer	81	3	8	55	22	15	63	16	13	78	13	1	66	13	13	38	22	32	92
SWM	61	6	55	81	20	21	102	14	6	57	56	9	75	32	15	44	35	43	122
NEM	44	5	43	58	18	16	80	9	3	82	10	0	64	24	4	41	25	26	92
Ariyalur																			
Winter	58	0	1	40	8	11	29	15	15	40	18	0	35	19	5	12	9	38	59
Summer	84	5	3	56	24	12	60	17	15	78	13	1	66	13	13	38	22	32	92
SWM	46	24	52	81	20	21	102	14	6	57	56	9	85	29	15	44	35	43	122
NEM	27	15	51	56	19	17	79	10	3	82	10	0	64	24	1	41	25	26	92

*C – Correct; U – Usable; IC - Incorrect

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