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Generation of weather windows to develop agro advisories for Tamil Nadu under automated weather forecast system

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ABSTRACT

With the objective of providing weather windows at block level of Tamil Nadu for developing agro advisories in respect of dominant crops, an exploratory research was conducted with four levels of rainfall, three levels of maximum temperature, three levels of minimum temperature, three levels of mean day relative humidity and three levels of wind speed. Adopting the permutation and combination methodology a total of 324 combinations from the identified levels of five weather elements were developed. Out of these combinations, 54 weather windows each with range of values for the identified weather elements were selected based on the validation of real-time weather data collected covering both temporal and spatial weather dimensions of the state.

Key words: Weather window, agro advisories, automated weather forecast system, generation

Management of monsoon rain for agricultural productivity is very critical for Tamil Nadu, since 45 per cent of the cultivable area is under dryland situation. Prof. M.S. Swaminathan used to spell out that under monsoon situation of limited water availability in India especially in Tamil Nadu, the role of climate/monsoon manager is very important. Tamil Nadu is the rain shadow area to Southwest monsoon (June-September) rainfall and hence the other monsoon namely the Northeast monsoon (October-December) is the life line monsoon for water resources of this geographical region. Though this is the fact that, the co-efficient of Southwest monsoon rainfall in India, considering it's high and low values of CV across different regions of India, it is relatively lesser (34%) than the Northeast monsoon seasonal rainfall (45%) which is dominant in Tamil Nadu and costal parts of Seemandhra, Kerala and Karnataka.

The weather based risks (inherited geo-location risk, transferable risk and risk that can be minimized by technology introduction) to crop productivity in Tamil Nadu is something different from majority of the states in India, wherein, except Tamil Nadu, the Southwest monsoon is dominant with contribution of 80 per cent of seasonal (88 cm) rainfall to annual rainfall, while it is 42 cm for Northeast monsoon seasonal rainfall in Tamil Nadu. Its contribution to Tamil Nadu annual rainfall is 48 per cent. Niranjan Kumar *et al*. (2013)from their study on the observed variability of monsoon drought over India reported that there was general increase in the intensity and present area affected by moderate drought during the recent decades as a result of climate and weather variability and this highlights the need of weather based farming decisions.

Stewart (1991) recommended response farming to the farmers of Australia wherein response farming advocates framing of crop plan with technologies based on forthcoming seasonal rainfall and proved that this approach was successful in terms of reducing the crop and animal production risks under rainfall variability. In India, India Meteorological Department (IMD) started weather services for the farmers from 1945 onwards to reduce weather risks (V&A Programme, 2009).However it did not contain the relevant information as required by the farmers for practical applications and hence was not much useful to the farming community.

Huge wheat grain loss had been reported at harvest stage in the wheat belt region of India with occurrence of Western disturbance since there was no facility in place to forecast such weather system movement under medium range scale. This affected food production in India with greater financial loss. This was discussed as a policy matter in the Department of Science and Technology, Government of India and thus the National Centre for Medium Range Weather Forecast (NCMRWF) came into existence. The NCMRWF was mandated to develop

Table 1 : Weather factors and their levels considered for the study

Weather factor / level	Rainfall (mm)	Maximum temperature(°C)	Minimum temperature(°C)	Day mean RH (%)	Wind speed (kmph)
L0	0	20-30	<15	20-40	<5
L1	0.1-20	30.1-35	15.1-20	40.1-70	5-15
L2	20.1-30	>35.0	20.1-30	>70.0	>15
L3	>30.0	-	-	-	-

medium range weather forecast over a resolution of agro-climate zonal level through supercomputers for three days from 1991 onwards and the same being communicated to different Agro Met Field Units(AMFU) to develop agro advisory for domain area farmers through mass media. Maini and Rathore (2011) from their study reported that farmers who adopted medium range agro advisories based on the weather forecast did accrue a net physical benefit of 10 to 15 per cent higher yield for the agricultural crops tested and also reduction in the cost of cultivation by 2 to 5 per cent as compared to the control farmers. Though, the medium range weather forecast at agro-climatic zone level had some advantages, still it was felt to down scale it to district level resolution so as to enhanced benefits to the farming community. Thus India Meteorological Department (IMD) started the district level weather forecast in association with the NCMRWF. The district level weather forecast for five days along with agro advisories are developed by IMD in association with different AMFU's spread over India including Tamil Nadu. These agro advisories are issued bi-weekly (every Tuesday and Friday) and communicated to the farmers through mobile Short Message Service (SMS).

Though the district level resolution is better than agroclimatic zonal level, issuing weather forecast at block level resolution with agro advisories for 6 days would be a better option to reduce the weather related risks in crop production. This approach of block level forecast would reduce the forecast error of topographic variability. With this in objective, the Government of Tamil Nadu has funded to Agro Climate Research Centre (ACRC) of Tamil Nadu Agricultural University (TNAU) under National Agricultural Technological Project (NATP) to install one Automatic Weather Station (AWS) each in all 385 blocks of the state. These blocks level AWSs will sense the weather information on day to day basis and communicate to the central server of Tamil Nadu Agricultural University. The block level weather forecast with a lead-time of 6 days will be developed using regional climate models (WRF) and stored in the server. The past 6 days observed weather and 6 days forecast developed will be integrated to develop weather based agro advisories at block level and communicated to the farmers through mobile SMS for the dominant crops.

This concept require generation of Weather Windows (WW) with ranges of important weather elements for Tamil Nadu covering both spatial and temporal dimensions, and for this exploratory research have been initiated by a team of Agro meteorologists at ACRC, TNAU.

MATERIALS AND METHODS

Considering the objective of developing weather windows for capturing the weather of Tamil Nadu across seasons covering temporal and spatial dimensions, four levels of rainfall, three levels of maximum temperature, three levels of minimum temperature, three levels of mean daily relative humidity (RH) and three levels of wind speed were taken for study as furnished in Table 1 and their permutations and combinations were generated (4x3x3x3x3).

Enough care was taken to identify each weather window from 324 combinations to capture the weather scenario of state more preciously. Based on the ground reality experiences in the field of daily weather situation of the state and also by validation with real-time weather data, the total 324 combinations were screened for short listing and thus 24 weather windows were selected. In addition caution was taken not to select more number of weather windows, since it will decrease the efficiency of agro advisories to be developed. For validating the initially developed 24 weather windows, weather data of2013 from Agro met Observatory of Tamil Nadu Agricultural University were used as suggested by Mooley (1994). He recommended that for validation in respect of cold weather

Table 2 : Selected weather windows (absolute range values)

WWNo	Absolute range values of weather elements					Name of the weather windows
	Rainfall (mm)	Maximum temperature (°C)	Minimum temperature (°C)	Mean RH (%)	Wind speed (kmph)	
1	0	20-30	<15	40-70&>70	<5	Dry cool humid weather
2	0	30.1- 35	15.1-20	40-70 &>70	<5	Dry warm humid weather
3	0	30.1-35	15.1-20	20-40	<5	Dry warm weather
4	0	>35.0	20.1-30	40-70 &>70	<5	Dry hot humid weather
5	0.1-30	20-30	<15	40-70 &>70	<5	Moist cool humid weather
6	0.1-30	30.1-35	15.1-20	40-70 &>70	<5	Moist warm humid weather
7	0.1-30	30.1-35	15.1-20	20-40	<5	Moist warm weather
8	0.1-30	>35.0	20.1-30	40-70 &>70	<5	Moist hot humid weather
9	>30	20-30	<15	40-70 &>70	<5	Wet cool humid weather
10	>30	30.1-35	15.1-20	40-70 &>70	<5	Wet warm humid weather
11	>30	30.1-35	15.1-20	20-40	<5	Wet warm weather
12	>30	>35.0	20.1-30	40-70 &>70	<5	Wet hot humid weather
13	0	20-30	<15	40-70&>70	>5	Dry cool humid weather with wind
14	0	30.1- 35	15.1-20	40-70 &>70	>5	Dry warm humid weather with wind
15	0	30.1-35	15.1-20	20-40	>5	Dry warm weather with wind
16	0	>35.0	20.1-30	40-70 &>70	>5	Dry hot humid weather with wind
17	0.1-30	20-30	<15	40-70 &>70	>5	Moist cool humid weather with wind
18	0.1-30	30.1-35	15.1-20	40-70 &>70	>5	Moist warm humid weather with wind
19	0.1-30	30.1-35	15.1-20	20-40	>5	Moist warm weather with wind
20	0.1-30	>35.0	20.1-30	40-70 &>70	>5	Moist hot humid weather with wind
21	>30	20-30	<15	40-70 &>70	>5	Wet cool humid weather with wind
22	>30	30.1-35	15.1-20	40-70 &>70	>5	Wet warm humid weather with wind
23	>30	30.1-35	15.1-20	20-40	>5	Wet warm weather with wind
24	>30	>35.0	20.1-30	40-70 &>70	>5	Wet hot humid weather with wind

Table 3 : Validation of weather for different seaoons of 2013.

Date	Rainfall (mm)	Maximum temperature (°C)	Minimum temperature (°C)	Daily mean RH (%)	Wind speed at 10 feet height (kmph)	WW No. (refer Table 2)
(a) Cold weather period						
15.1.2013	0	31.2	16.7	61.0	6.4	14
16.1.2013	0	31.2	19.0	66.0	8.3	14
17.1 2013	0	30.2	20.2	59.0	7.8	NA
18.1.2013	0	29.5	18.5	62.0	6.0	NA
19.1.2013	0	30.4	16.8	65.0	4.7	2
20.1.2013	0	31.5	17.6	61.5	3.9	2
Total/mean	0*	30.7**	18.1**	62.4**	6.2**	14
(b) Hot weather period						
15.4.2013	0	37.0	25.7	63.0	5.0	16
16.4.2013	0	35.6	24.5	66.0	7.3	16
17.4 2013	0	36.0	25.4	62.5	6.1	16
18.4.2013	0	37.0	25.0	63.5	5.2	16
19.4.2013	0	35.5	23.4	60.0	5.0	16
20.4.2013	0	36.0	23.6	56.5	4.5	4
Total/mean	0*	36.2**	24.6**	61.9**	5.5**	16
(c) Sowthwest monsoon period						
15.7.2013	0	32.0	24.2	67.0	12.1	NA
16.7.2013	0	31.0	25.2	68.5	13.9	NA
17.7 2013	0.8	30.0	23.4	67.5	16.6	NA
18.7.2013	0	30.5	24.6	70.0	15.6	NA
19.7.2013	1.2	29.5	23.4	80.0	16.7	NA
20.7.2013	7.6	26.0	22.5	75.0	15.0	NA
Total/mean	9.6*	32.0**	24.2**	67.0**	12.1**	20
(d) Northeast monsoon period						
15.10.2013	0	32.8	23.2	70.5	4.8	NA
16.10.2013	22.6	32.8	22.4	78.0	5.3	NA
17.10.2013	17.2	31.6	21.7	79.5	5.0	NA
18.10.2013	0	31.0	21.7	75.0	2.6	NA
19.10.2013	10.6	32.6	21.2	76.5	4.7	NA
20.10.2013	42.4	31.0	20.8	83.0	3.4	NA
Total/mean	92.8*	32.0**	21.8**	77.1**	4.3**	12

* 6 days total; NA not available, mean of 6 days.

Table 4 : Revised weather windows (absolute range values)

WWNo	Absolute range values of weather elements					Name of the weather windows
	Rainfall (mm)	Maximum temperature (°C)	Minimum temperature (°C)	Daily Mean RH (%)	Wind speed (kmph)	
1	0	<20	<15	> 40	<5	Dry cool humid weather
2	0	20-30	<15	> 40	<5	Dry cool humid weather
3	0	20-30	15.1-20	> 40	<5	Dry cool humid weather
4	0	20-30	20.1-30	> 40	<5	Dry cool humid weather
5	0	30.1- 35	15.1-20	> 40	<5	Dry warm humid weather
6	0	30.1-35	15.1-20	<40	<5	Dry warm weather
7	0	30.1-35	20.1-30	> 40	<5	Dry warm humid weather
8	0	>35.0	15.1-20	> 40	<5	Dry hot humid weather
9	0	>35.0	20.1-30	> 40	<5	Dry hot humid weather
10	0.1-30	<20	<15	> 40	<5	Moist cool humid weather
11	0.1-30	20-30	<15	> 40	<5	Moist cool humid weather
12	0.1-30	20-30	15.1-20	> 40	<5	Moist cool humid weather
13	0.1-30	20-30	20.1-30	> 40	<5	Moist cool humid weather
14	0.1-30	30.1-35	15.1-20	> 40	<5	Moist warm humid weather
15	0.1-30	30.1-35	15.1-20	<40	<5	Moist warm weather
16	0.1-30	30.1-35	20.1-30	> 40	<5	Moist warm humid weather
17	0.1-30	>35.0	15.1-20	> 40	<5	Moist hot humid weather
18	0.1-30	>35.0	20.1-30	> 40	<5	Moist hot humid weather
19	>30	<20	<15	> 40	<5	Wet cool humid weather
20	>30	20-30	<15	> 40	<5	Wet cool humid weather
21	>30	20-30	15.1-20	> 40	<5	Wet cool humid weather
22	>30	20-30	20.1-30	> 40	<5	Wet cool humid weather
23	>30	30.1-35	15.1-20	> 40	<5	Wet warm humid weather
24	>30	30.1-35	15.1-20	<40	<5	Wet warm weather
25	>30	30.1-35	20.1-30	> 40	<5	Wet warm humid weather
26	>30	>35.0	15.1-20	> 40	<5	Wet hot humid weather

27	>30	>35.0	20.1-30	> 40	<5	Wet hot humid weather
28	0	<20	<15	> 40	>5	Windy dry cool humid weather
29	0	20-30	<15	> 40	>5	Windy dry cool humid weather
30	0	20-30	15.1-20	> 40	>5	Windy dry cool humid weather
31	0	20-30	20.1-30	> 40	>5	Windy dry cool humid weather
32	0	30.1- 35	15.1-20	> 40	>5	Windy dry warm humid weather
33	0	30.1-35	15.1-20	<40	>5	Windy dry warm weather
34	0	30.1-35	20.1-30	> 40	>5	Windy dry warm humid weather
35	0	>35.0	15.1-20	> 40	>5	Windy dry hot humid weather
36	0	>35.0	20.1-30	> 40	>5	Windy dry hot humid weather
37	0.1-30	<20	<15	> 40	>5	Windy moist cool humid weather
38	0.1-30	20-30	<15	> 40	>5	Windy moist cool humid weather
39	0.1-30	20-30	15.1-20	> 40	>5	Windy moist cool humid weather
40	0.1-30	20-30	20.1-30	> 40	>5	Windy moist cool humid weather
41	0.1-30	30.1-35	15.1-20	> 40	>5	Windy moist warm humid weather
42	0.1-30	30.1-35	15.1-20	<40	>5	Windy moist warm weather
43	0.1-30	30.1-35	20.1-30	> 40	>5	Windy moist warm humid weather
44	0.1-30	>35.0	15.1-20	> 40	>5	Windy moist hot humid weather
45	0.1-30	>35.0	20.1-30	> 40	>5	Windy moist hot humid weather
46	>30	<20	<15	> 40	>5	Windy wet cool humid weather
47	>30	20-30	<15	> 40	>5	Windy wet cool humid weather
48	>30	20-30	15.1-20	> 40	>5	Windy wet cool humid weather
49	>30	20-30	20.1-30	> 40	>5	Windy wet cool humid weather
50	>30	30.1-35	15.1-20	> 40	>5	Windy wet warm humid weather
51	>30	30.1-35	15.1-20	<40	>5	Windy wet warm weather
52	>30	30.1-35	20.1-30	> 40	>5	Windy wet warm humid weather
53	>30	>35.0	15.1-20	> 40	>5	Windy wet hot humid weather
54	>30	>35.0	20.1-30	> 40	>5	Windy wet hot humid weather

Table 5 : Validation of weather windows of Table 4 with block level AWS mean real-time data of six days

District	Block	Observation dates	Rainfall* (mm)	Maximum (°C) temperature**	Minimum temperature** (°C)	Daily mean RH** (%)	Wind speed** (kmph)	WW No. (refer Table 4)
Ariyalur	Andimadam	1.1.12 to 6.1.12	0	31.1	23.3	84.8	2.2	7
Coimbatore	Anamalai	2.3.12 to 7.3.12	0	35.6	22.9	73.9	2.6	9
Cuddalore	Annagramam	4.6.12 to 9.6.12	0	39.4	27.0	57.3	7.6	36
Dharmapuri	Dharmapuri	11.8.12 to 16.8.12	0	33.1	23.5	61.2	6.1	34
Dindugal	Dindugal	4.10.12 to 9.10.12	66.5	35.7	22.9	65.2	4.6	27
Erode	Bhavanisagar	8.12.12 to 13.12.12	0	32.1	18.9	78.0	2.5	5
Kanchepuram	Kanchepuram	1.2.12 to 6.2.12	0	29.1	18.8	85.3	4.09	3
Kanyakumari	Agasteesvaram	20.9.12 to 25.9.12	0	33.6	25.5	78.5	5.78	34
Krishnagiri	Bargur	4.4.12 to 9.4.12	0	37.15	21.5	53.8	4.2	9
Karur	Paramathi	10.5.12 to 15.5.12	0	35.8	25.5	**62.0**	3.0	9
Madurai	Alanganallur	19.7.12 to 24.7.12	0	35.6	25.3	52.7	5.4	36
Nagapattinam	Nagapattinam	1.11.12 to 6.11.12	0	29.8	24.7	**79.3**	6.9	31
Namakkal	Pallipalayam	23.2.12 to 28.2.12	0	37.1	17.9	60.0	2.9	8
Perambalur	Perambalur	15.3.12 to 20.3.12	0	36.4	21.9	61.1	4.35	9
Pudukkotai	Annavasal	1.7.12 to 6.7.12	0	37.5	25.5	80.0	5.9	36
Ramanathapuram	Ramanathapuram	1.10.12 to 6.10.12	0	34.5	27.3	65.2	5.6	34
Salem	Salem	2.5.12 to 7.5.12	1.0	36.5	25.9	65.4	4.7	18
Sivaganga	Kalaiyarkoil	5.12.12 to 10.12.12	0	32.1	22.1	60.0	3.03	7
Thanjovur	Kumbakonam	7.8.12 to 12.8.12	19.0	35.8	25.4	69.7	6.98	45
The Nilgiris	Ooty	30.7.12 to 4.8.12	1.5	19.1	13.3	75.9	7.8	37
Theni	Andipatti	28.10.12 to 2.11.12	7.5	29.0	22.3	57.08	2.2	13
Thiruvallur	Ellapuram	10.4.12 to 15.4.12	0	37.3	25.6	65.0	9.1	36
Tuticorin	Alvarthirunagari	8.11.12 to 13.11.12	74.0	31.6	24.2	81.0	3.7	25
Thiruvannamalai	Arani	3.4.12 to 8.4.12	0	37.0	22.1	68.3	0.78	9
Thiruvarur	Kodavasal	12.6.12 to 17.6.12	0	36.6	26.4	66.9	8.4	36
Thiruchirapalli	Manigandam	7.8.12 to 12.8.12	0	40.0	27.8	61.9	7.96	36
Thirunelveli	Thengasi	18.10.12 to 23.10.12	165.5	29.7	23.1	90.4	9.5	52
Thiruppur	Dharapuram	4.5.12 to 9.5.12	2.5	36.0	25.1	66.0	9.68	45
Vellore	Katpadi	20.7.12 to 25.7.12	1.0	33.3	25.2	70.2	3.72	16
Villupuram	Chinnasalem	30.1.12 to 4.2.12	0	29.4	20.2	72.6	5.2	31
Virudhunagar	Aruppukottai	21.9.12 to 26.9.12	0	35.8	23.4	61.8	4.2	9

*6 days total; **mean of 6 days

period, 6 days of January month can be taken, while it is 6 days from April for summer month, 6 days from July for Southwest monsoon season and 6 days from October for Northeast monsoon. While validating the Coimbatore weather it was realized that the identified 24 weather windows need further revision. Hence re-exercise was done by addition of another 30 weather windows from the pool of 324 combinations to the strength of 24 weather windows selected already after careful examination, the number of weather windows was brought to 54 so as to capture the entire weather situations of Tamil Nadu across seasons without any miss. These 54 weather windows were validated again with weather data collected from AWS installed in each block of the state.

RESULTS AND DISCUSSIONS

Out of 324 permutations and combinations, with knowledge of Tamil Nadu daily weather scenario, initially 24 weather windows were shortlisted as given in Table 2. Each weather element in the weather window has range of absolute values so as to capture the weather scenario preciously without any miss and also to reduce the number of weather windows to be used for providing agroadvisories. For example, in case of weather window(WW1)in Table 2, the absolute value of rainfall is 0 mm, combined with maximum temperature range of 20–30°C, minimum temperature of less than 15°C, mean day relative humidity between 40-70& greater than 70 per cent and wind speed ranging between 0 to 5 kmph.

Validation of the weather windows given in Table 2 was done with real-time weather data of year 2013 collected from Agro met Observatories of TNAU and the season-wise results are presented in Table 3.

From Table 3 with reference to weather windows in Table 2 it may be noted that the mean of 6 days for cold weather period matched with the weather window 14 (WW14), likewise for hot weather period with WW16, for Southwest weather period with WW20 and for Northeast monsoon period with WW12 indicating that the each weather element's absolute value varied with seasons and this said to be the natural variability arising due to variation in falling of sun's rays on Earth with its rotation around Sun. While, scanning the daily values of each six days of hot weather period the weather values recorded in each date and 6 days mean were accurate at 90 per cent level to indicate the weather window 16 (Table 2). However, for Southwest and Northeast monsoon periods it emerged that daily values did not fall into any of the 24 weather window identified although the mean of the 6 days weather elements indicated weather window 20 and 12, respectively. Likewise, the accuracy for the cold weather period was also poor (33 per cent). Considering the limitations of the values of weather elements in Table 2 and anomalies noted for different seasons a need was felt for inclusion of some more windows from the pool to the weather windows in Table 2. Based on the revisit made, another 30 weather windows were added to the already identified 24 weather window making the total to 54 and presented in Table 4.

The sample data for validation were so chosen that for each district, one block was selected. From AWS of the block, daily data for six days at random were collected, mean arrived for all weather elements except rainfall, where six days total were considered and used for validation of weather windows given in Table 4. Validation was done for both mean values and individual date values of the data collected from AWS of each block for year 2012 and the results are given in Table 5.

The validation results given in Table 5 indicated that the mean 6 days weather data of all the blocks taken for the study (different dates) fell within the 54 weather windows given in Table 4. The daily weather data for five weather elements was also validated with the weather windows given in Table 4. The result endorses the validity of the weather windows chosen in Table 4indicating thereby that these 54 weather windows are able to capture the weather scenarios of Tamil Nadu both spatially and temporally and hence can be used to provide agro advisories under automated weather forecast system in Tamil Nadu. If at all any climate change situation arises in future, the absolute values given in the Table 5 may require some micro-level adjustments.

CONCLUSION

The objective of developing weather windows for Tamil Nadu covering both spatial and temporal dimension of weather system was achieved through identification of 54 weather windows by employing permutation and combination methodology followed by validation of 54 weather windows with real-time weather data. These 54 weather windows can be employed with confidence for developing agro advisories for individual crops for

dissemination to the farmers in domain area under automated agro advisory services.

REFERENCES

Mooley, D.A. (1994). Indian Climatology. Short-term training notes on agrometeorological data monitoring and management conducted by NCMRWF at Indian Institute of Tropical Meteorology , Pune from 24. 10. 1994 to 3.11. 1994.

Niranjan Kumar, K., M. Rajeevan, D.S. Pai, A.K. Srivastava, B. Preethi. (2013). On the observed variability of monsoon droughts over India. *Weather and Climate Extremes*. 1: 42–50.

Parvinder Maini and L.S. Rathore. (2011). Economic impact assessment of the Agrometeorological Advisory Service of India. *Current Science*. 101(10): 1296 - 1310.

Stewart, K. I. (1991). Principles and performance of response farming. In: "Climatic Risk in Crop Production: Models and Management for the Semiarid Tropics and Subtropics". (Eds. R.C. Muchow, R.C. and Bellamy, J.A.) pp. 361-382. (CAB International, Wallingford, UK.

V&A Programme. (2009). Vulnerability and Adaptation experiences from Rajasthan and Andhra Pradesh: A Weather - based farming model for communities, SDC V&A Programme, India. Cited from http://www.swiss-cooperation. admin.ch /india/ressources / resource_en_192488.pdf

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