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Improving efficiency of block-level agrometeorological advisory system by exploiting reuse: A study in Telangana

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ABSTRACT

India Meteorological Department (IMD) has started block-level level agromet advisory (AA) service from the year 2015 and is currently operating in a few blocks of each state across India. In a block-level AA service, on every Tuesday and Friday, AA is being prepared for each block based on the block-level Medium Range weather Forecast (MRF). In this paper, we propose a framework to improve the preparation of block-level AA by modeling a weather situation as "Category-based Weather Condition (CWC)" and exploiting both "temporal reuse" and "spatial reuse" of AA based on the similarity among CWCs. The weather data analysis for 12 blocks of Telangana by considering the phenophase-specific CWCs of Rice crop showed that there is a scope to improve the efficiency of block-level AA bulletin preparation process by exploiting reuse.

Keywords: Agromet advisory, Weather condition, Reuse, Similarity, Categorical Weather Condition, Weather forecast.

India Meteorological Department (IMD) has introduced the Integrated Agromet Advisory Service (AAS) since 2008 in collaboration with the Indian Council of Agricultural Research (ICAR) and State Agricultural Universities (SAUs) based on the district-level Medium-Range Forecasts (MRF) through 130 Agro-Meteorological Field Units (AMFUs).

IMD has taken up the block-level AAS based on block-level MRF since 2015 and it is currently operating in a few blocks of each district. In due course of time, to improve the coverage, IMD is planning to provide block-level AAS to 6500 blocks across 660 districts all over India through District Agromet Units (DAMUs) (Newsreport, 2019). In the block-level AAS, the Agromet Expert (AE) has to prepare AA for each block every Tuesday and Friday based on the block level MRF. Each AE at DAMU has to prepare AA for several blocks within the stipulated time.

Normally, for a given duration, the weather situation of the nearby blocks may not be different from each other. In such a scenario, if the weather situation of the nearby blocks is similar, then is a scope to reduce human effort of preparing AA by exploiting *spatial reuse*. Furthermore, if the weather situation of the current season matches with a weather situation of preceding seasons, then is scope to reduce human effort by exploiting temporal reuse. In this paper, we have proposed a data analysis framework to improve the efficiency of AE for preparation of block-level AA by exploiting both temporal as well as spatial reuse.

The evaluation studies (Maini, 2011), Nirwal *et.al* (2019), Khichar *et.al* (2020) have indicated that the farmers who have followed AA have benefitted considerably. Efforts were made to ease the process of preparation of AAs by exploiting reuse (Reddy, 2014) , Balasubrmanian *et.al* (2014), (Mamatha, 2014), (Mamatha, 2017), and Mamatha *et.al* (2019). In the software engineering domain, the notion of *reuse* plays a key role in minimizing human efforts (Srivastava, 2002).

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Table 1: Sample block MRF for Chevella block (2018).

B1	01-Jan	02-Jan	03-Jan	04-Jan	05-Jan
Tmin	14.7	14.3	15	14.7	12.7
Tmax	31.9	33.4	32.1	31.5	31.4
RF	0	0	0	0	0

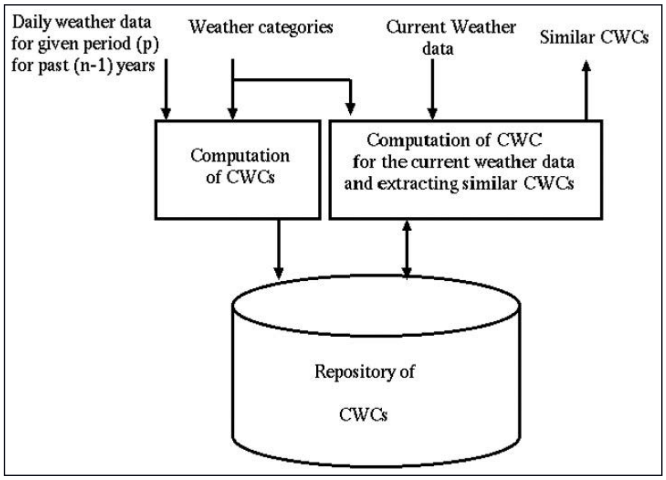

Fig. 1: Components of the proposed framework

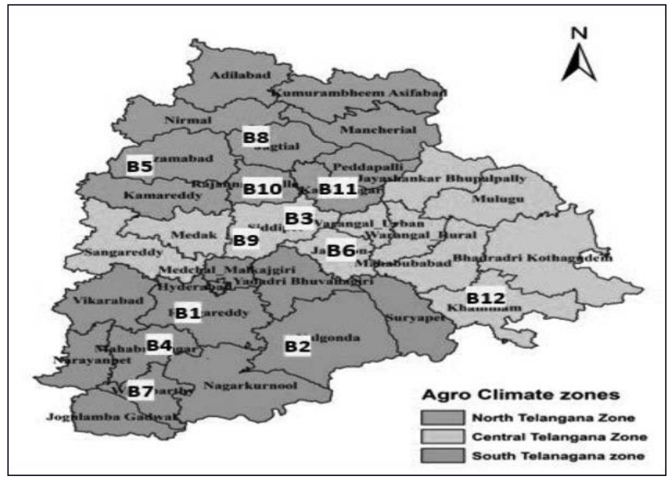

Fig. 2: Zone-wise block representation of the selected blocks

MATERIALS AND METHODS

We explain the proposed framework after explaining the following concepts: weather condition (WC), category-based WC and similarity among WCs.

The weather situation of a given location is modelled with WC.

Definition 1. Weather Condition (WC): The WC is defined as WC(i, s, d, V, ψ (V)). Here, "i" denotes the location identifier, "s" indicates the start date, "d" indicates the duration of weather data in days, "V" is the set of weather variables and ψ(V) is the value of each weather variable in "V" that is equal to the summary statistics for "d".

Example 1: For the weather data of Table 1, WC with i=1, d=5 and s=1-JAN-2018 is (1, 1-JAN-2018, 5, {14.28, 32.06, 0}). Here, the values of minimum temperature (T_{min}) and maximum temperature (T_{max}) are computed as the average value from 1-JAN-2018 to 5-JAN-2018. The values of rainfall (RF) are calculated by computing the summation of the RF values from 1-JAN-2018 to 5-JAN-2018.

It can be observed that AEs do not prepare a different suggestion for a slight change in the weather variable values. Normally, the range of each weather variable can be divided into categories based on the requirements of the domain. With category information, the notion of Category-based WC is defined as follows.

Definition 2. Category-based WC for Bi (CWC): The category-based WC is represented as CWC(i, s, d, V, C(ψ (V))). The notations "i", "d", "s", and "V" have essentially the same semantics as in Definition 1. Here, C(ψ(V)) represents the category for each 'V' Î "V".

Example 2: For the WC formed in Example 1, CWC with i=1, d=5 and s=1-JAN-2018 is CWC(1, 1-JAN-2018, 5, RF, C(0)) = CWC(B1, 1-JAN-2018, 1, RF, "No Rain"). Here, C(0) = "No Rain".

Normally, the weather phenomena repeats in cycles i.e., periodically. For example, weather phenomena repeats yearly. Similarly, given several consecutive years, weather phenomena may repeat at the sub-cycle level, which we designate as "periods". For example, winter seasons of a given sequence of years are called "periods".

Definition 3. Cycle, Period: A cycle is a sequence of consecutive days. Moreover, a period is also a sequence of consecutive days. However, the number of days in the given period is less than or equal to the corresponding cycle.

Table 2: Experimental Settings

Name	Description
Data set	Daily weather data for 2015, 2016, 2017, 2018 and 2019
Weather variables	Tmin,Tmax, RF
Duration (d)	5 days
Weather categories	IMD weather categories [Table 3]
Period types	Phenophases of Rice Crop (Kharif and Rabi) [Table 4]
Block names (12)	B1-Chevella; B2-Chityala; B3-Gajwel; B4-Jadcherla; B5-Jakranapalle; B6-Jangoan; B7-Kothakota; B8-Sarangapur; B9-Siddipet; B10-Sirisilla; B11-Thimmapur; B12-Thirumalayapalem [Fig. 2]
Zones	North (B5, B8, B10, B11); Central (B1, B2, B4, B7); South (B3, B6, B9, B12)

Table 3: Weather categories defined by IMD (IMD's forecaster guide, 2008)

Weather variable name	Range	Category name
Temperature (deg C) (Deviation from normal)	-1,0,1	Little change
	2 or -2	Rise /Fall
	3 to 4	Appreciable Rise
	-3 to -4	Appreciable Fall
	5 to 6	Marked Rise
	-5 to -6	Marked Fall
	>7	Large Rise
	<=-7	Large Fall
Rain fall (mm)	0-0	No Rain
	0.1-2.4	Very Light Rain
	2.5-7.5	Light Rain
	7.6-35.5	Moderate Rain
	35.6-64.4	Rather Heavy Rain
	64.5-124.4	Heavy Rain
	124.5-244.4	Very Heavy Rain
	>=244.5	Extremely Heavy Rain

Table 4: Duration of rice crop phenophases for *Kharif* and *Rabi* seasons

Period type (pt)	*Kharif* (Jun-Oct)	*Rabi* (Dec-Mar)
Sowing	W27-W32(6)	W50-W1(4)
Transplanting	W32-W36(5)	W1-W4(4)
Maximum tillering	W35-W38(4)	W5-W9(5)
Panicle initiation	W39-W44(6)	W9-W12(4)
Flowering	W43-W48(6)	W12-W16(5)
Maturity	W48-W52(5)	W16-W20(5)

Definition 4. Similar CWCs: Let "p" and "q" be CWCs, where p = CWC<i, s, d, V, C(ψ(V))> and q = CWC<j, s, d, V, C(ψ(V))> for a given "d". We say, "p" and "q" are similar if the category values of the respective weather variables in "V" are equal.

Proposed framework

The basic idea is to exploit the potential of both *temporal reuse* and *spatial reuse*. Regarding *temporal reuse*, we exploit the fact that AA of WCs of preceding periods for given block (Bi) can be reused to prepare AA for the WC of current period of Bi. Regarding *spatial reuse*, we exploit the fact that AA prepared for the WC of the current duration for the given block, can be reused to prepare AA for the nearby blocks.

The components of the proposed framework are given in Fig.1. The input to the system is weather data for 'm' blocks and weather categories defined by IMD. The output is similar CWCs for the given weather data. The framework is divided into two parts: (i) computation of CWCs for past weather data and (ii) computation of CWC for the current weather data and extracting similar CWCs.

(i). *Computation of CWCs for the past weather data*

The input to this step is weather data of past years (n-1) and weather categories defined by IMD. By considering the weather category information, CWCs of each of "m" blocks are calculated for (n-1) years (refer

Table 5: CP values for the phenophases of the rice during *Kharif* season (*Temporal reuse*)

Block	2015 (I)	2016 (II)	2017 (III)	2018 (IV)	2019 (V)	2015 (I)	2016 (II)	2017 (III)	2018 (IV)	2019 (V)	2015 (I)	2016 (II)	2017 (III)	2018 (IV)	2019 (V)
	Sowing					**Transplanting**					**Maximum tillering**				
B1	-	28.6	14.3	28.6	100	-	0	0	40	100	-	0	0	0	100
B2	-	0	28.6	42.9	57.1	-	0	0	40	20	-	0	25	75	25
B3	-	42.9	42.9	14.3	14.3	-	0	0	40	80	-	0	0	50	100
B4	-	0	71.4	14.3	85.7	-	0	0	40	80	-	25	25	100	50
B5	-	42.9	28.6	57.1	42.9	-	0	20	20	100	-	25	0	50	50
B6	-	0	28.6	42.9	42.9	-	0	0	20	60	-	0	0	25	50
B7	-	0	42.9	71.4	71.4	-	0	0	40	80	-	25	0	25	50
B8	-	0	42.9	57.1	57.1	-	20	0	60	60	-	75	25	50	25
B9	-	0	14.3	57.1	100	-	0	0	60	80	-	0	0	25	75
B10	-	28.6	28.6	28.6	28.6	-	40	0	20	60	-	0	0	0	75
B11	-	28.6	0	28.6	28.6	-	20	0	20	20	-	50	25	0	25
B12	-	42.9	42.9	71.4	42.9	-	20	40	80	60	-	50	25	25	50
	Panicle Initiation					**Flowering**					**Maturity**				
B1	-	28.6	14.3	42.9	42.9	-	42.9	42.9	42.9	28.6	-	0	83.3	50	83.3
B2	-	42.9	57.1	57.1	14.3	-	57.1	71.4	71.4	85.7	-	0	66.7	50	100
B3	-	42.9	28.6	85.7	57.1	-	42.9	71.4	71.4	85.7	-	16.7	100	16.7	66.7
B4	-	28.6	71.4	85.7	85.7	-	42.9	71.4	85.7	71.4	-	16.7	33.3	83.3	83.3
B5	-	0	71.4	57.1	42.9	-	42.9	85.7	57.1	71.4	-	33.3	66.7	33.3	66.7
B6	-	0	28.6	57.1	57.1	-	57.1	57.1	42.9	71.4	-	16.7	83.3	66.7	66.7
B7	-	42.9	42.9	42.9	28.6	-	42.9	71.4	57.1	71.4	-	16.7	50	50	83.3
B8	-	28.6	28.6	71.4	42.9	-	14.3	85.7	28.6	71.4	-	0	83.3	50	50
B9	-	42.9	14.3	85.7	42.9	-	57.1	71.4	57.1	85.7	-	16.7	16.7	50	100
B10	-	42.9	0	57.1	0	-	42.9	0	42.9	85.7	-	16.7	16.7	33.3	50
B11	-	0	28.6	85.7	0	-	42.9	85.7	28.6	71.4	-	16.7	66.7	50	16.7
B12	-	28.6	42.9	57.1	28.6	-	57.1	28.6	57.1	71.4	-	66.7	33.3	33.3	100

Definition 2). The computed CWCs of each block are stored in the Repository of CWCs.

(ii). *Computation of CWC for the current weather data and extracting similar CWCs*

The input to this step is the current weather data of a given block Bi. The corresponding similar CWCs are extracted from the Repository of CWCs **(**refer to Definition 4).

Study area and experimental settings

Weather data (Tmin, Tmax and RF) of five years (2015-2019) is collected for the twelve blocks (Fig. 2 and Table 2) of Telangana state. The experimental settings are presented in Table 2. We compute CWCs by considering Tmin, Tmax and RF. We have employed weather categories of Tmin, Tmax and RF as given by IMD (IMD's forecaster guide, 2008) (Table 3). The categories of Tmin and Tmax are assigned by considering the corresponding normal value for each block. The experiments were conducted by computing the five-day duration (d=5) CWCs. In the experiments, the CWCs of the Kharif and Rabi phenophases of the Rice Crop for each year from 2015 to 2019 are considered. The duration of each phenophase in terms of standard weeks is presented in Table 4. For experiments, on *temporal reuse*, CWCs over a period are considered. Given CWCs of a sequence of periods of phenophases of Rice, it could be reused for similar CWCs in the subsequent periods. For *spatial reuse*, CWCs of the current block are compared with the CWCs of nearby blocks for the current period.

Performance metric: To compute the extent of both *tempora*l and *spatial* reuse, we employ coverage

Table 6: CP values for the phenophases of the Rice during *Rabi* season (*Temporal reuse*)

Block	2015 (I)	2016 (II)	2017 (III)	2018 (IV)	2019 (V)	2015 (I)	2016 (II)	2017 (III)	2018 (IV)	2019 (V)	2015 (I)	2016 (II)	2017 (III)	2018 (IV)	2019 (V)
	Sowing					**Transplanting**					**Maximum tillering**				
B1	-	0	33.3	33.3	66.7	-	66.7	66.7	33.3	33.3	-	83.3	16.7	50	-
B2	-	0	66.7	33.3	66.7	-	100	33.3	100	66.7	-	100	33.3	83.3	-
B3	-	0	100	0	66.7	-	66.7	66.7	100	33.3	-	100	0	33.3	-
B4	-	0	0	66.7	66.7	-	100	66.7	0	33.3	-	100	16.7	33.3	-
B5	-	66.7	33.3	33.3	33.3	-	66.7	66.7	0	0	-	16.7	66.7	66.7	-
B6	-	0	66.7	66.7	66.7	-	66.7	66.7	33.3	33.3	-	66.7	16.7	83.3	-
B7	-	33.3	100	33.3	33.3	-	100	33.3	66.7	33.3	-	100	50	66.7	-
B8	-	0	66.7	33.3	33.3	-	0	66.7	33.3	33.3	-	0	66.7	16.7	-
B9	-	0	0	33.3	66.7	-	66.7	100	33.3	33.3	-	66.7	50	66.7	-
B10	-	0	0	0	33.3	-	0	33.3	0	0	-	0	16.7	50	-
B11	-	0	0	66.7	33.3	-	0	0	66.7	33.3	-	0	33.3	66.7	-
B12	-	0	33.3	66.7	33.3	-	100	66.7	66.7	33.3	-	66.7	50	83.3	-
	Panicle Initiation					**Flowering**					**Maturity**				
B1	-	0	33.3	100	-	-	20	20	80	-	-	25	50	75	-
B2	-	66.7	33.3	100	-	-	60	40	80	-	-	25	0	50	-
B3	-	0	100	100	-	-	20	40	60	-	-	25	25	50	-
B4	-	0	0	100	-	-	20	40	80	-	-	25	0	0	-
B5	-	0	66.7	100	-	-	0	80	40	-	-	75	0	50	-
B6	-	0	0	33.3	-	-	40	40	80	-	-	50	25	25	-
B7	-	0	66.7	33.3	-	-	20	40	80	-	-	50	0	50	-
B8	-	0	33.3	100	-	-	20	40	100	-	-	50	25	75	-
B9	-	0	0	100	-	-	40	40	100	-	-	25	50	75	-
B10	-	0	33.3	66.7	-	-	20	40	40	-	-	0	100	50	-
B11	-	0	66.7	33.3	-	-	20	40	60	-	-	0	75	25	-
B12	-	0	66.7	33.3	-	-	20	40	60	-	-	25	0	75	-

percentage (CP) as a performance metric. Given CWCs of a set of periods, we compute the number of CWCs of current period that are similar to the CWCs of the given set of period(s). The definition of CP is as follows.

Definition 5: Coverage Percentage (CP): Consider CWCs of the given period “x” and the set “p” of periods. CP(x/p) is given by the percentage of CWCs of “x” which appear in the CWCs of “p” periods.

RESULTS AND DISCUSSION

Results on temporal reuse

The results of CP values for rice crop phenophases of *Kharif* are reported in Table 5. Considering the sowing phase, the CP value for 2015 does not exist as it is the reference year (starting year). The CP value of 2016 for sowing phase is 28.6%. It is equal to the number of CWCs in the sowing phase of 2016 that are common to the CWCs of the sowing phase of 2015. Similarly, the CP of 2017 for the sowing phase is 14.3%. It is equal to the percentage of CWCs in the sowing phase of 2017 that are common to the CWCs of the sowing phase of both 2015 and 2016. The CP values for Rabi are computed in a similar manner and reported in Table 6. The results in

Table 7: CP values for the phenophases of the Rice crop during Kharif season (*spatial reuse*)

North zone						Central zone						South zone					
Block	2015	2016	2017	2018	2019	Block	2015	2016	2017	2018	2019	Block	2015	2016	2017	2018	2019
Sowing																	
B5	100	100	50	75	37.5	B1	100	75	50	100	87.5	B3	75	75	37.5	62.5	50
B8	50	75	37.5	75	37.5	B2	75	100	50	50	50	B6	87.5	100	37.5	75	50
B10	87.5	100	50	12.5	62.5	B4	75	87.5	100	50	50	B9	100	100	87.5	62.5	62.5
B11	87.5	100	62.5	37.5	37.5	B7	87.5	100	50	50	50	B12	87.5	50	62.5	75	62.5
Transplanting																	
B5	100	100	66.7	50	66.7	B1	50	66.7	100	50	66.7	B3	100	83.3	66.7	50	83.3
B8	50	100	33.3	50	83.3	B2	100	100	66.7	66.7	33.3	B6	66.7	100	0	50	66.7
B10	83.33	100	33.3	16.7	66.7	B4	100	100	50	66.7	66.7	B9	83.3	100	50	83.3	100
B11	100	100	33.3	16.7	50	B7	83.3	83.3	100	50	66.7	B12	83.3	83.3	33.3	50	50
Maximum Tillering																	
B5	100	60	60	60	40	B1	60	100	60	40	60	B3	100	100	20	80	80
B8	40	100	60	60	60	B2	40	80	60	40	20	B6	60	100	0	60	60
B10	60	100	0	0	20	B4	60	100	60	60	20	B9	100	100	0	100	60
B11	80	100	80	0	40	B7	80	80	60	60	20	B12	60	40	20	40	40
Panicle Initiation																	
B5	100	100	62.5	62.5	100	B1	87.5	50	50	50	87.5	B3	62.5	87.5	12.5	75	87.5
B8	100	100	25	75	50	B2	87.5	87.5	75	37.5	25	B6	87.5	100	12.5	50	87.5
B10	87.5	100	12.5	12.5	75	B4	87.5	87.5	75	75	50	B9	100	100	50	87.5	75
B11	100	100	62.5	50	50	B7	87.5	100	37.5	37.5	62.5	B12	75	62.5	37.5	75	75
Flowering																	
B5	100	100	100	62.5	75	B1	87.5	100	62.5	50	50	B3	87.5	100	62.5	75	62.5
B8	100	100	62.5	62.5	75	B2	87.5	100	62.5	12.5	62.5	B6	100	100	87.5	50	87.5
B10	87.5	100	12.5	75	50	B4	100	100	50	37.5	50	B9	100	100	75	87.5	75
B11	87.5	100	87.5	87.5	50	B7	87.5	87.5	75	50	37.5	B12	62.5	62.5	100	62.5	50
Maturity																	
B5	83.33	100	100	83.3	100	B1	83.3	66.7	100	33.3	66.7	B3	83.3	66.7	66.7	66.7	83.3
B8	100	83.3	83.3	33.3	100	B2	66.7	100	100	83.3	66.7	B6	83.3	100	66.7	66.7	66.7
B10	100	100	0	33.3	83.3	B4	83.3	100	50	66.7	66.7	B9	100	100	100	83.3	100
B11	83.33	100	83.3	50	66.7	B7	50	100	100	33.3	83.3	B12	33.3	66.7	83.3	33.3	83.3

Tables 5 and 6 showed that, except for a few years, CP of each phenophase improves over years. It can be noted that the CP value in 2019 is about 40% for most of the blocks and phenophases. But, for some phenophases, the CP value is reported as zero due to the deviation in RF. Overall, the results showed a significant temporal reuse among CWCs.

Results on spatial reuse

Spatial reuse has been computed by dividing 12 blocks into three (north/central/south) agro-climatic zones of Telangana (Fig. 2, Table 2). In this experiment, given a block and phenophase, the computed CP is equal to the percentage of CWCs of phenophase of that block, which are common to the CWCs of phenophases of other

Table 8: CP values for the phenophase of the rice crop during Rabi season (*spatial reuse*)

North zone					Central zone					South zone				
Block	2015	2016	2017	2018	Block	2015	2016	2017	2018	Block	2015	2016	2017	2018
Sowing														
B5	75	100	100	50	B1	75	75	100	25	B3	100	75	100	50
B8	100	50	100	50	B2	75	100	100	50	B6	100	100	75	50
B10	100	100	0	25	B4	75	100	25	50	B9	100	100	50	50
B11	100	100	75	25	B7	50	75	100	50	B12	25	100	100	25
Transplanting														
B5	75	75	100	75	B1	100	75	100	25	B3	100	100	100	75
B8	75	75	75	75	B2	75	100	50	75	B6	100	100	100	100
B10	100	100	25	50	B4	75	100	75	75	B9	100	100	100	75
B11	100	100	100	25	B7	100	100	75	25	B12	75	100	75	100
Maximum Tillering														
B5	66.67	100	83.33	100	B1	100	100	83.33	83.33	B3	66.67	100	100	50
B8	50	100	83.33	50	B2	66.67	100	66.67	100	B6	100	100	83.33	50
B10	100	100	16.67	33.33	B4	100	100	66.67	50	B9	100	100	66.67	83.33
B11	100	100	83.33	83.33	B7	100	100	83.33	66.67	B12	66.67	83.33	83.33	83.33
Panicle Initiation														
B5	75	100	75	50	B1	100	100	75	75	B3	100	100	50	50
B8	75	75	100	25	B2	50	100	100	100	B6	100	100	50	75
B10	100	100	25	75	B4	75	100	75	100	B9	100	100	25	50
B11	100	100	50	75	B7	75	100	100	50	B12	50	100	75	75
Flowering														
B5	100	83.33	66.67	50	B1	83.33	83.33	50	100	B3	66.67	83.33	66.67	83.33
B8	83.33	50	83.33	83.33	B2	100	100	83.33	83.33	B6	100	100	50	100
B10	100	100	33.33	66.67	B4	100	83.33	33.33	83.33	B9	100	100	33.33	83.33
B11	100	100	83.33	83.33	B7	100	50	100	83.33	B12	83.33	50	66.67	100
Maturity														
B5	100	83.33	66.67	50	B1	80	100	20	40	B3	60	80	20	40
B8	83.33	50	83.33	83.33	B2	100	80	100	80	B6	100	100	60	80
B10	100	100	33.33	66.67	B4	100	100	80	80	B9	100	80	40	40
B11	100	100	83.33	83.33	B7	100	40	60	60	B12	60	40	60	100

blocks in the same zone. Data presented in Tables 7 and 8 showed CP values of Kharif and Rabi respectively. Consider the sowing phase of north zone for Kharif shown in Table 7. We have to observe the results column-wise. Observe the results for year 2015 (column). The CP value of 2015 for sowing phase is 100%, which is equal to the number of CWCs of B5 in the sowing phase of 2015 that are common to the CWCs of combined blocks B8, B10 and B11 during the sowing phase of year 2015. Similarly, the CP of 2016 for the sowing phase is 100%, which is equal to the number of CWCs of B5 in the sowing phase of 2016 that are common to the combined CWCs of B8, B10 and B11 during the sowing phase of 2016. The CP values for Rabi are computed in a similar manner and reported in Tables 8. The results showed that except for a few years, CP of each phenophase increases over years.

Table 9: CP values for the phenophases the rice crop during Kharif season (*temporal and spatial reuse*)

North zone						Central zone						South zone					
Block	2015	2016	2017	2018	2019	Block	2015	2016	2017	2018	2019	Block	2015	2016	2017	2018	2019
Sowing																	
B5	-	100	75	87.5	62.5	B1	-	75	50	100	100	B3	-	75	87.5	62.5	87.5
B8	-	75	62.5	100	87.5	B2	-	100	50	62.5	62.5	B6	-	100	50	87.5	62.5
B10	-	100	62.5	37.5	87.5	B4	-	87.5	100	62.5	100	B9	-	100	87.5	87.5	87.5
B11	-	100	62.5	75	100	B7	-	100	75	75	62.5	B12	-	75	62.5	100	87.5
Transplanting																	
B5	-	100	100	50	100	B1	-	83.3	83.3	100	100	B3	-	100	66.7	83.3	100
B8	-	100	83.3	50	100	B2	-	100	66.7	83.3	66.7	B6	-	100	0	50	100
B10	-	100	66.7	50	100	B4	-	100	100	100	83.3	B9	-	100	83.3	66.7	100
B11	-	100	66.7	66.7	83.3	B7	-	83.3	83.3	83.3	100	B12	-	83.3	100	83.3	50
Maximum Tillering																	
B5	-	60	60	100	100	B1	-	100	60	100	100	B3	-	100	20	100	100
B8	-	100	80	60	80	B2	-	80	80	80	40	B6	-	100	0	60	80
B10	-	100	20	60	100	B4	-	100	100	100	80	B9	-	100	40	100	80
B11	-	100	80	40	100	B7	-	100	80	100	80	B12	-	80	40	80	60
Panicle Initiation																	
B5	-	100	87.5	87.5	100	B1	-	50	87.5	75	100	B3	-	87.5	37.5	100	100
B8	-	100	50	87.5	87.5	B2	-	87.5	87.5	75	75	B6	-	100	37.5	62.5	100
B10	-	100	25	50	87.5	B4	-	87.5	87.5	87.5	87.5	B9	-	100	87.5	87.5	100
B11	-	100	62.5	87.5	100	B7	-	100	75	62.5	87.5	B12	-	100	87.5	87.5	87.5
Flowering																	
B5	-	100	100	100	75	B1	-	100	87.5	75	62.5	B3	-	100	87.5	100	87.5
B8	-	100	62.5	75	75	B2	-	100	87.5	87.5	100	B6	-	100	87.5	75	100
B10	-	100	12.5	87.5	87.5	B4	-	100	87.5	87.5	87.5	B9	-	100	100	100	75
B11	-	100	87.5	87.5	100	B7	-	87.5	75	62.5	50	B12	-	100	100	62.5	50
Maturity																	
B5	-	100	100	83.3	100	B1	-	83.3	100	66.7	100	B3	-	66.7	66.7	83.3	83.3
B8	-	83.3	83.3	83.3	100	B2	-	100	100	83.3	100	B6	-	100	100	83.3	100
B10	-	100	16.7	66.7	100	B4	-	100	83.3	100	83.3	B9	-	100	100	83.3	100
B11	-	100	100	66.7	100	B7	-	100	100	100	100	B12	-	100	83.3	100	100

It can be noted that the CP value varies from 25% to 100%. But, for some phenophases, the CP value is reported as zero due to the deviation in RF. Overall, the results show significant spatial reuse among CWCs.

Temporal and spatial reuse

In this experiment, the CP of each block is computed by comparing both *temporal* and *spatial* CWCs of each block. The results of both *temporal* and *spatial* CP values of Kharif and Rabi are presented in Tables 9 and 10. Except for a few, almost all CP values for all phenophases in 2019 exceed 70%. The results also show that the extent of reuse varies from 50% to 100% in the phenophases of Rice crop. Overall, the results show that the CP values have improved significantly with both *spatial* and *temporal* reuse.

Table 10: CP values for the phenophases of the rice crop during Rabi season (*temporal and spatial reuse*)

North zone						Central zone						South zone					
Block	2015	2016	2017	2018	2019	Block	2015	2016	2017	2018	2019	Block	2015	2016	2017	2018	2019
Sowing																	
B5	-	100	100	50	100	B1	-	75	100	50	75	B3	-	75	100	50	75
B8	-	50	100	75	100	B2	-	100	100	50	100	B6	-	100	75	50	100
B10	-	100	0	75	75	B4	-	100	75	50	75	B9	-	100	100	50	100
B11	-	100	100	25	100	B7	-	100	100	75	100	B12	-	100	100	50	100
Transplanting																	
B5	-	75	100	100	50	B1	-	75	100	75	100	B3	-	100	100	100	75
B8	-	75	75	75	75	B2	-	100	100	100	100	B6	-	100	100	100	100
B10	-	100	25	100	75	B4	-	100	50	100	100	B9	-	100	75	75	100
B11	-	100	100	75	75	B7	-	100	100	75	100	B12	-	100	100	100	100
Maximum Tillering																	
B5	-	100	83.3	100	-	B1	-	100	83.3	83.3	-	B3	-	100	100	83.3	-
B8	-	100	83.3	66.7	-	B2	-	100	66.7	100	-	B6	-	100	100	83.3	-
B10	-	100	16.7	66.7	-	B4	-	100	66.7	83.3	-	B9	-	100	83.3	83.3	-
B11	-	100	83.3	83.3	-	B7	-	100	100	83.3	-	B12	-	100	83.3	83.3	-
Panicle Initiation																	
B5	-	100	75	75	-	B1	-	100	100	75	-	B3	-	100	50	50	-
B8	-	75	100	50	-	B2	-	100	100	100	-	B6	-	100	50	75	-
B10	-	100	50	75	-	B4	-	100	75	100	-	B9	-	100	75	100	-
B11	-	100	100	75	-	B7	-	100	100	100	-	B12	-	100	100	100	-
Flowering																	
B5	-	83.3	66.7	100	-	B1	-	83.3	50	100	-	B3	-	83.3	66.7	100	-
B8	-	50	83.3	83.3	-	B2	-	100	83.3	100	-	B6	-	100	50	100	-
B10	-	100	83.3	100	-	B4	-	83.3	66.7	100	-	B9	-	100	83.3	100	-
B11	-	100	83.3	100	-	B7	-	66.7	100	100	-	B12	-	50	66.7	100	-
Maturity																	
B5	-	100	60	80	-	B1	-	100	60	40	-	B3	-	80	40	80	-
B8	-	80	60	100	-	B2	-	80	100	80	-	B6	-	100	60	80	-
B10	-	100	80	80	-	B4	-	100	80	80	-	B9	-	80	100	100	-
B11	-	100	60	60	-	B7	-	100	100	100	-	B12	-	40	80	100	-

CONCLUSION

We have proposed an IT-based framework by exploiting both *temporal* reuse and *spatial* reuse based on the notion of Category-based WC (CWC) to improve the efficiency of block-level agromet advice preparation. The data analysis results on the weather data from 2015 to 2019 on 12 blocks of three zones of Telangana state show that there is a scope to improve AA preparation process by exploiting reuse. If we analyse for more years, the reuse will improve further due to the coverage of diverse weather situations. Overall, the results show that there is scope to exploit reuse to improve the block-level AA preparation process by exploiting both *spatial* and *temporal* reuse.

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