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 AA 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), Balasubramanian 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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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, \( \psi (V) \)). 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 \( \psi (V) \) 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 (Tmin) and maximum temperature (Tmax) 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(\( \psi (V) \)))). The notations “i”, “d”, “s”, and “V” have essentially the same semantics as in Definition 1. Here, C(\( \psi (V) \)) 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, 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.
Definition 4. Similar CWCs: Let “p” and “q” be CWCs, where \( p = CWC_{i, s, d, V, C(\psi(V))} \) and \( q = CWC_{j, s, d, V, C(\psi(V))} \) 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 | Sowing | Transplanting | Maximum tillering |
|-------|--------|---------------|-------------------|
|       | 2015   | 2016          | 2017  | 2018  | 2019  | 2015  | 2016  | 2017  | 2018  | 2019  |
| B1    | -      | 28.6          | 14.3  | 28.6  | 100   | -     | 0     | 0     | 40    | 100   |
| B2    | -      | 0             | 28.6  | 42.9  | 57.1  | -     | 0     | 0     | 40    | 20    |
| B3    | -      | 42.9          | 14.3  | 14.3  | -     | -     | 0     | 0     | 80    | -     |
| B4    | -      | 0             | 71.4  | 14.3  | 85.7  | -     | 0     | 0     | 40    | 80    |
| B5    | -      | 42.9          | 28.6  | 57.1  | 42.9  | -     | 0     | 20    | 20    | 100   |
| B6    | -      | 0             | 28.6  | 42.9  | 42.9  | -     | 0     | 0     | 20    | 60    |
| B7    | -      | 0             | 42.9  | 71.4  | 71.4  | -     | 0     | 0     | 40    | 80    |
| B8    | -      | 0             | 42.9  | 28.6  | 57.1  | -     | 0     | 20    | 60    | -     |
| B9    | -      | 0             | 14.3  | 57.1  | 100   | -     | 0     | 0     | 60    | 80    |
| B10   | -      | 28.6          | 28.6  | 28.6  | 28.6  | -     | 0     | 0     | 20    | 60    |
| B11   | -      | 28.6          | 28.6  | 28.6  | 28.6  | -     | 0     | 0     | 20    | 60    |
| B12   | -      | 42.9          | 42.9  | 42.9  | 42.9  | -     | 0     | 0     | 40    | 80    |

Panicle Initiation     Flowering          Maturity

| Block | 2015   | 2016   | 2017   | 2018   | 2019   | 2015   | 2016   | 2017   | 2018   | 2019   |
|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| B1    | -      | 28.6   | 14.3   | 42.9   | 42.9   | -      | 42.9   | 42.9   | 28.6   | -      |
| B2    | -      | 42.9   | 57.1   | 14.3   | 14.3   | -      | 57.1   | 71.4   | 71.4   | 85.7   |
| B3    | -      | 42.9   | 28.6   | 85.7   | 57.1   | -      | 42.9   | 71.4   | 71.4   | 85.7   |
| B4    | -      | 28.6   | 71.4   | 85.7   | 85.7   | -      | 42.9   | 71.4   | 71.4   | 85.7   |
| B5    | -      | 0      | 71.4   | 57.1   | 42.9   | -      | 42.9   | 85.7   | 57.1   | 71.4   |
| B6    | -      | 0      | 28.6   | 57.1   | 57.1   | -      | 57.1   | 57.1   | 42.9   | 71.4   |
| B7    | -      | 0      | 14.3   | 57.1   | 100    | -      | 57.1   | 57.1   | 42.9   | 71.4   |
| B8    | -      | 42.9   | 42.9   | 42.9   | 42.9   | -      | 42.9   | 71.4   | 57.1   | 71.4   |
| B9    | -      | 42.9   | 14.3   | 85.7   | 42.9   | -      | 57.1   | 71.4   | 57.1   | 85.7   |
| B10   | -      | 28.6   | 28.6   | 71.4   | 42.9   | -      | 14.3   | 85.7   | 28.6   | 71.4   |
| B11   | -      | 0      | 28.6   | 85.7   | 0      | -      | 42.9   | 85.7   | 28.6   | 71.4   |
| B12   | -      | 28.6   | 42.9   | 57.1   | 28.6   | -      | 57.1   | 28.6   | 57.1   | 71.4   |

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 temporal and spatial reuse, we employ coverage
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 both 2015 and 2016. The CP values for Rabi are computed in a similar manner and reported in Table 6. The results in

| 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 | 66.7 | 33.3 | 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 | - |

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

| Phenophase          | North zone | Central zone | South zone |
|---------------------|------------|--------------|------------|
|                     | 2015       | 2016         | 2017       | 2018       | 2019       | 2015       | 2016         | 2017       | 2018       | 2019       | 2015       | 2016         | 2017       | 2018       |
| Sowing              | B5         | 100          | 100         | 50         | 75         | 37.5       | B1         | 100          | 75         | 50         | 100        | 87.5       | 75           | 75         | 37.5        | 62.5        | 50         |
|                     | B8         | 50           | 75          | 37.5       | 75         | 37.5       | B2         | 75           | 100        | 50         | 50         | 50         | 87.5         | 100        | 37.5        | 75          | 50         |
|                     | B10        | 87.5         | 100         | 50         | 12.5       | 62.5       | B4         | 75           | 87.5       | 100        | 50         | 50         | 87.5         | 100        | 87.5        | 62.5        | 62.5       |
|                     | B11        | 87.5         | 100         | 62.5       | 37.5       | 37.5       | B7         | 87.5         | 100        | 50         | 50         | 50         | 87.5         | 100        | 62.5        | 75          | 62.5       |
| Transplanting       | B5         | 100          | 100         | 66.7       | 50         | 66.7       | B1         | 50           | 66.7       | 100        | 50         | 66.7       | 37.5         | B3           | 100        | 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         | 50          | 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           | 0           | B7         | 80           | 80         | 60         | 60         | 20         | B12          | 60          | 100         | 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         | 87.5         | 100        | 62.5        | 75          | 62.5       | 75         |
|                     | 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         | 83.3         | 66.7       | 100        | 83.3       | 66.7       | B6           | 83.3        | 83.3        | 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 blocks.
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 8: CP values for the phenophase of the rice crop during Rabi season (spatial reuse)

|                  | North zone | Central zone | South zone |
|------------------|------------|--------------|------------|
|                  | 2015  | 2016  | 2017  | 2018  | 2015  | 2016  | 2017  | 2018  | 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   | 75    | 50    |
| B8               | 75    | 75    | 75    | 75    | B2    | 75    | 100   | 50    | 75    | B6    | 100   | 100   | 100   | 50    |
| 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   | 80    | 80    | 80    | B9    | 100   | 80    | 40    | 40    |
| B11              | 100   | 100   | 83.33 | 83.33 | B7    | 100   | 40    | 60    | 60    | B12   | 60    | 40    | 60    | 100   |

Improving efficiency of block-level agrometeorological advisory system
Table 9: CP values for the phenophases the rice crop during Kharif season (*temporal and spatial reuse*)

| Block  | North zone | Central zone | South zone |
|--------|------------|--------------|------------|
|        | 2015 | 2016 | 2017 | 2018 | 2019 | 2015 | 2016 | 2017 | 2018 | 2019 | 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 | 100 |
| **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 | 100  | 62.5 |
| **Maturity** | | | | | | | | | | | | | | | |
| B5     | 100 | 100 | 100  | 83.3 | 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.
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 agrometeorological advisory 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.

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

| Block | North zone | Central zone | South zone |
|-------|------------|--------------|------------|
|       | 2015 2016 2017 2018 2019 Block | 2015 2016 2017 2018 2019 Block | 2015 2016 2017 2018 2019 Block |
| **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 |
temporal reuse.

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