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Rainfall Probability Analysis & Crop Planning for Sundergarh district of Odisha

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ABSTRACT
Block level daily rainfall dataof Sundergarh district present in North-western Plateau Agro-climatic zone of Odishawere analyzedfor 23 years (1995-2017) to study the expected amount of rainfall at 3 different probability levels i.e., 90% which is considered assured rainfall, 75% probability level which is considered as dependable rainfall and usually associated with no risk, and 50% probability level is associated with 50% risk. Rainfall probability analysis was done using Incomplete Gamma distribution, to estimate annual and weekly rainfall probability. Analysis revealed that the long term mean rainfall in Sundergarh district is 1273 mm which is not equally distributed during year. More than 85% of annual rainfall is received in monsoon months (June-September) and remaining during post-monsoon and pre-monsoon together.Results of rainfall probability analysis shows that the expected annual rainfall in the district at 90%, 75% and 50% probability levels are 858.6 mm, 1024.7 mm and 1234.7 mmrespectively.Expected rainfall is less than 5 mm is remaining weeks at 75% probability level. Probability of getting 20mm rainfall or more is high between SMW 25 to 38, hence crop can be planned during this period considering the information contained in block weather advisory. Sundergarh comes under moist sub-humid climate where humid period is more than 12 weeks duration and the rainfall is twice that of PET. Hence, paddy based cropping system is suitable. Medium duration rice varieties can easily be grown with little fear of drought at reproductive stage. Moreover, the residual soil moisture after the harvest of rice can be effectively utilised for raising another short duration crop like lentil, mustard, greengram and biri in winter.
Keywords:*Rainfall probability analysis, Incomplete Gamma distribution, crop planning*

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INTRODUCTION
Indian economy is mainly based on agriculture and this agriculture and water management options are primarily influenced by the rainfall pattern. Increased climate variability has made rainfall patterns more inconsistent and unpredictable in the country increasing the recurrence of drought or drought like situations. In India, rainfed agriculture is practiced over several agro-ecological regions constituting 60% of total cropped area and has a large share of cropped area under rice (42%), pulses (77%), oilseeds (66%) and coarse cereals (85%).[1] The success and failure of agricultural production mainly depends on the prevailing weather conditions.Here, Agro-climatic characterization using appropriate parameters becomes a very good tool to identify the homo climates,to delineate regions and periods of water deficiencies so that agricultural activities or farm operations can be planned accordingly suiting to the regional climate.
Rainfall statistical analysis at different time step i.e., annual, seasonal, monthly and weekly for a region can be helpful in designing water harvesting and flood control structures.

Characteristics of rainfall vary both spatially and temporally and therefore is not the same throughout the year or in different years on any given date. The same is true for different regions where we can see high variability in spatial rainfall characteristics. Owing tothe development of short duration hybrids, importance of rainfall analysis atshorter timestep is needed. A month's period is too long when compared with the life span of these crops. Therefore under rain fed conditions, detailed analysis of rainfall pattern on a weekly basis would be appropriate to evaluate the chances of success and failure of any crop. Under rain fed conditions, growing season exist usually in the monsoon months. Hence, for agricultural crop planning, knowledge about the variability in the amount of weekly rainfall and duration of monsoon season is very much needed.

The crucial problem affecting agriculture is the persistence in receiving a specific amount of rainfall during the critical growing period. In light of the above,rainfall probability analysis is essential for planning the crop and farm operations well in time and to bring out agriculture potential of a region. Several techniques have been developed for determining rainfall probability distribution and best fit probability distribution functions such as Normal, Gumbel, Weibull and Pearson type distribution. Therefore, this study aims to analyze 23 years (1995-2017) of daily block level rainfall data for Sundergarh district following Incomplete Gamma distribution Technique and Markov chain modelusing 'Weathercock'in order to identify the period of water scarcity and the probability level associated in receiving specific amount of rainfall during a given Standard Meteorological Week (SMW).

MATERIAL AND METHODS

Study area

Sundergarh district forms the North-Western border of Odisha, geographically extends between $21^0$35' N and $22^0$32' N latitudes and $83^0$32' E and $85^0$22' E longitudes, spanning over an area of 9712 square kilometres, out of which 3130 square kilometres area is net sown. The district is comprised of 17 blocks viz. Balisankara, Bargaon, Bisra, Bonai, Gurundia, Hemgiri, Lathikata, Lephripara, Lahunipara, Kutra, Koida, Sundergarh, Nuagaon, Kuarmunda, Rajgangpur, Subdega and Tangarpali. The district soil type is dominated by Red soil (26.5%) followed by sandy loam (17%), sandy soil (8.4%), black soil (3.3%) and others including brown forest and laterite soil. There are five sources of irrigation in the district, like Canals, Tanks, lift irrigation, water bodies including rainwater harvesting structures and Open well. Cereals, pulses, oilseeds and coarse cereals are major crops grown in the district. [2]

Data and Methods

Daily rainfall data of 23 years (1995-2017) recorded at 17 raingauge station located in each block have been collected from Department of Revenue and Disaster management, Special Relief Commissioner, Government of Odisha. The amount of weekly rainfall at two different probability levels i.e. 50% and 75%were computed for each standard week through fitting Incomplete Gamma Distribution model by using block wise weekly rainfall data as input. Annual and weekly rainfall probabilities were calculated through the module "Incomplete Gamma Probabilities.exe in Weather cock". The probability level of 60% is considered as dependable without risk; 50% is associated with 50% risk and 20% is very risk from the crop point of view.[3]

In this study, weekly rainfall values have been computed from daily data series and were used for estimation of initial, conditional and consecutive dry and wet spell analysis based on Markov chain probability model [4][5] using 'Weathercock'. In this method, 20 mm or more rainfall in a week is considered as wet week otherwise dry as the previous researchers [5, 6] also used 20 mm as the threshold value.

RESULTS & DISCUSSION

The mean annual rainfall of the district is 1273 mm which shows great variability.The expected annual rainfall at 90%, 75% and 50% probability levels are 858.6mm, 1024.7 mm and 1234.7 mm respectively (Table 1). At block level, the mean annual rainfall was highest in Bonai (1553 mm) and least in Rajgangpur (1077 mm). Expected rainfall at 90% probability level was found to be above 1000 mm in three blocks namely, Bonai, Hemgir and Lahunipara. However, it was less than 700 mm in three blocks Bargaon, Rajgangpur

and Tangarpali at same probability level. The block receiving minimum and maximum amount of rainfall at this probability level is Rajgangpur (541.5 mm) and Bonai (1048.3 mm).

At 75% probability level, which is considered as dependable rainfall without risk, rainfall was above 1150 mm in four blocks, namely, Bonai, Hemgir, Lahunipara and Lathikata. The rainfall was below 900 mm for the blocks, namely Bargaon, Rajgangpur and Tangarpali. At 50% probability level, only one block(Rajgangpur) is expected to receive below 1000 mm rainfall. The blocks expected to be receiving annual rainfall exceeding 1300 mm at same probability were Bonai, Gurundia, Hemgir, Lahunipara and Lathikata.

Amount of rainfall received at weekly time step is more important than the total rainfall received annuallyfor planning farm operations.Therefore, the amount of rainfall that can be received during each standard week have been computed at two different probability levels (50%, 75%) with their mean value by fitting Incomplete Gamma Distribution model and have been presented in Figure 1.

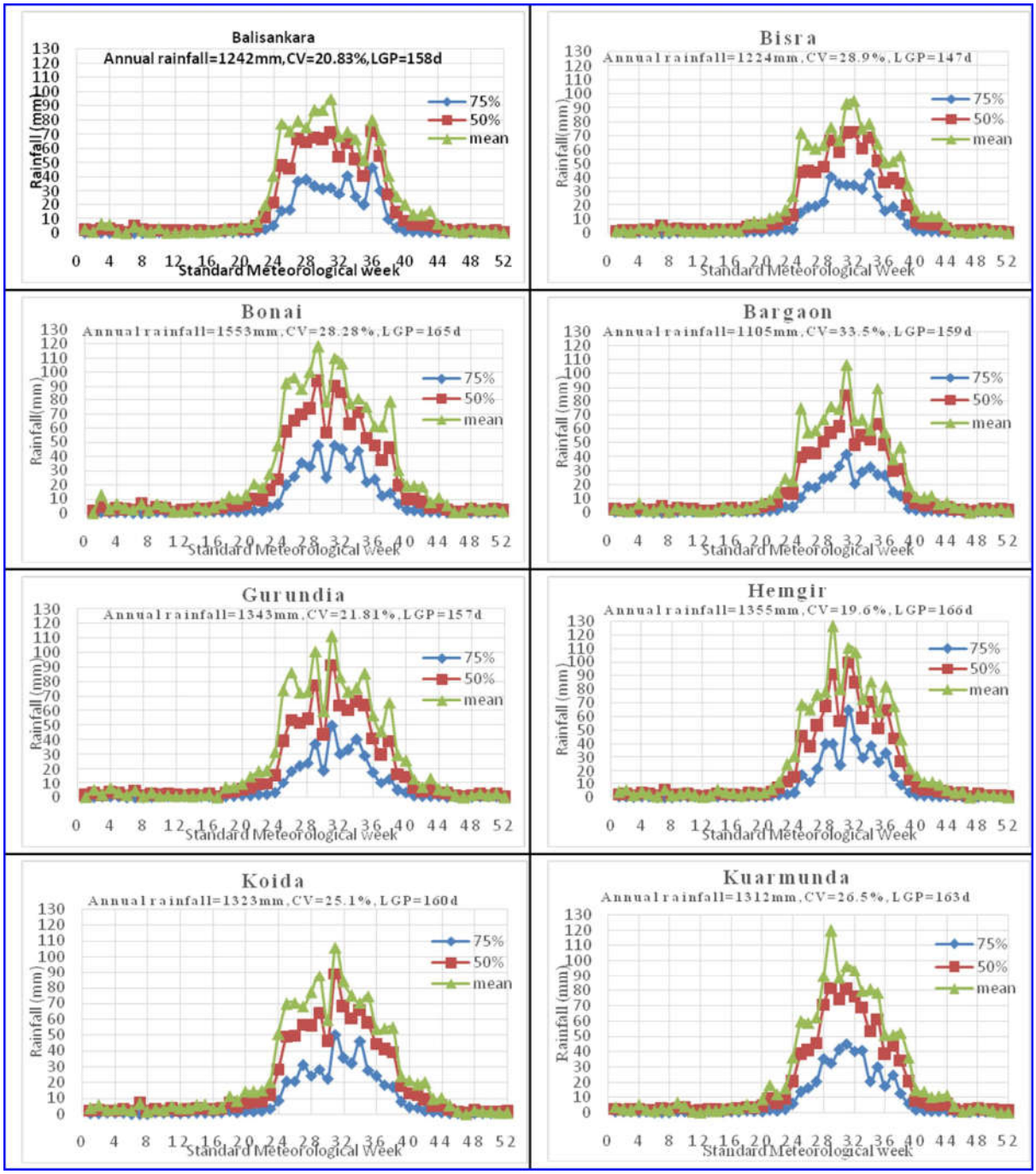
Table 1: Expected annual rainfall at 90%, 75% and 50% probability levels

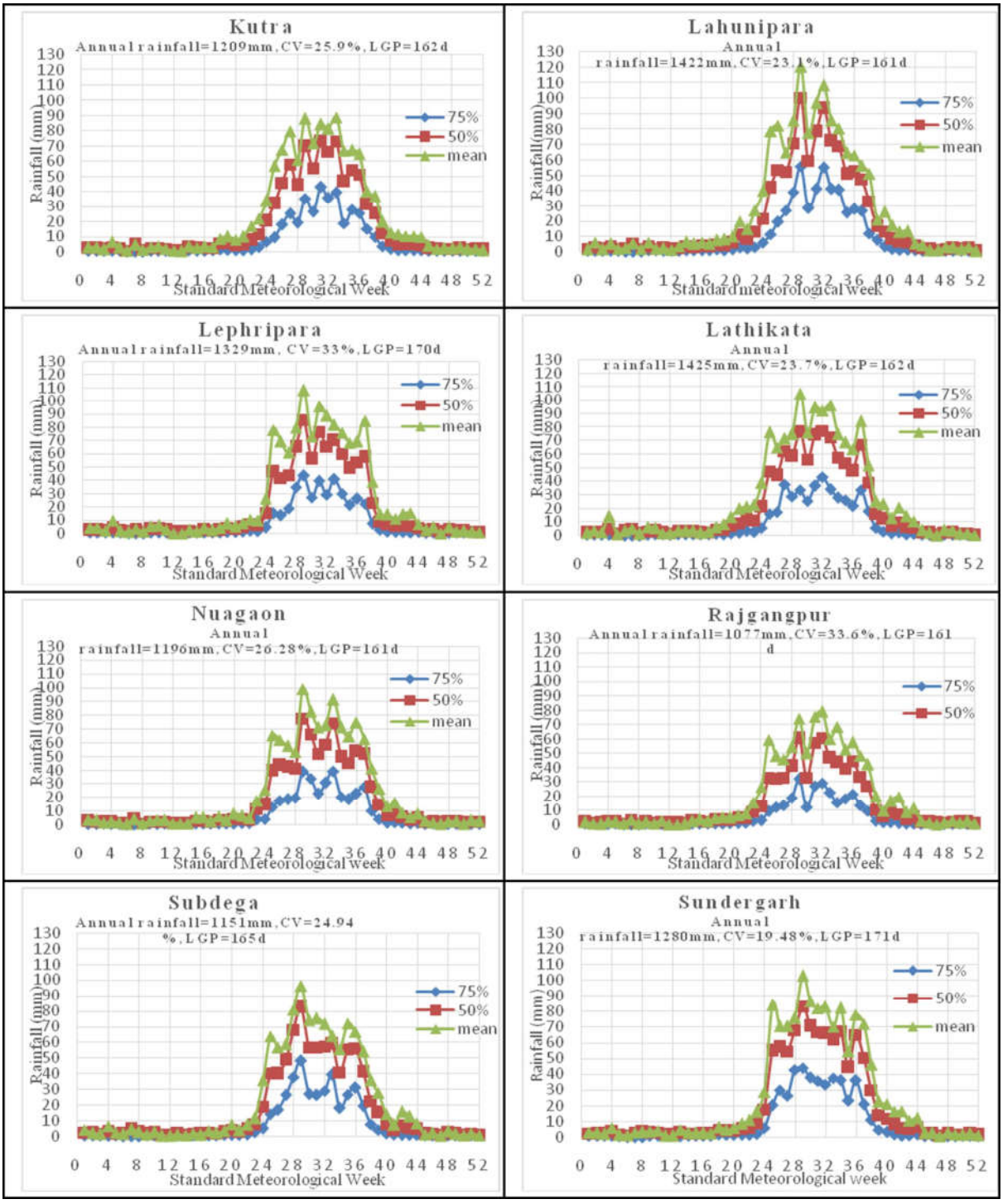
S.No	Block	Expected rainfall (mm) at		
		90%	75%	50%
1	Balisankara	923.3	1059.6	1226.3
2	Bargaon	699.3	877.8	1109.2
3	Bisra	790.1	956.7	1168.1
4	Bonai	1048.3	1261.8	1531.7
5	Gurundia	977	1122.6	1300.8
6	Hemgir	1027.4	1165.9	1333.9
7	Koida	892.6	1068	1288.9
8	Kuarmunda	914.9	1081.4	1289.2
9	Kutra	826.3	980.5	1173.6
10	Lahunipara	1030.7	1194.2	1395.6
11	Lathikata	996.3	1169.3	1384.2
12	Lephripara	762.2	968.1	1238.1
13	Nuagaon	747.3	920.2	1142.2
14	Rajgangpur	541.5	719.1	959.3
15	Subdega	773.3	921.1	1106.5
16	Sundergarh	978.6	1114.5	1279.8
17	Tangarpali	666.4	838.7	1063.2
District		**858.6**	**1024.7**	**1234.7**

The probability of receiving more than 20mm rainfall at 75% probability level starts from SMW 25 and continues up to 38 week. This coincides with the monsoon season. It is less than 20 mm during rest of the year. From the figure 1, it can also be confirmed that monsoon is the main growing season when about 86.8% of the annual rainfall is received. Other than the monsoon season, pre-monsoon and post-monsoon weeks receive very less rainfall. Furthermore, the amount of rainfall received at any given SMW varies in different blocks. So based on this information suitable water harvesting structures can be established in the region where excess rainwater can be stored and utilized as supplementary irrigation to kharif crops during long dry spells and also to the winter crops. This will increase the growing period available to the farmers.

From Table 2, it can be observed that in most of the blocks at least 10 mm rainfall is received after 24th SMW which continues up to 39 SMW. This duration coincides with the onset and cessation of rainfall. July and August months contributes more than 50% of the annual rainfall. The expected rainfall amount is more than 20mm between SMW 27 to SMW 37 which can be utilized for transplanting paddy in medium and lowlands and other kharif pulses, vegetables in upland. At 50% probability, more than 20mm rainfall is expected during SMW 24 and 39. This means that farming activities can be started after 24th SMW and since rice is a staple food for the country, paddy seedlings can be grown by this time.

Figure 1: weekly mean and expected rainfall at 50% and 75% probability levels in different blocks





Probability of Dry and wet spell using Markov chain model

The initial probability of occurrence of wet spell was <10 % during SMW 1- 21, more than 60% during SMW 24-39, and then afterwards again decreased to less than 10 % during SMW 45-52. On the contrary, the initial probability of occurrence of dry spell was found to be very high (>80%) during SMW 1-21 and 41-52, whereas it was relatively very less during22-40 (Table 3).

The conditional probability of a wet spell followed by another wet spell, P(W/W) was very high (>75%) during SMW 25 – 38. However, P(D/W) was very low(<25%) during this period and that of a dry week followed by wet week is very high (>75%) during this period SMW 25 – 39 except week 32 when probability was 0%. There was 50% conditional probability

during SMW 38. On the contrary, probability of getting two dry spells one after another is high in most of the weeks except during SMW 25-37 when probability is less than 50%.

Probability of consecutive dry and wet spell using Markov chain model

The result showed that probability of occurrence of two consecutive dry weeks was >75% from week 1 to 21 and also from week 43 to 52 at rainfall limit of 20 mm. Probability of occurrence of two consecutive wet weeks was >70% from week 25th to 37th. Week 1 to 20 and 43 to 52 SMW of the year remained under stress on an average, as there were more than 70% chances of occurrence of three consecutive dry weeks(Table 4). Probability of consecutive wet for 3 weeks was high (>65%) during 25 - 36 SMW. The probability of occurrence of 4 weeks dry spell was >80% from beginning of year to SMW 19 and from SMW 43 until end of December. On the other hand, probability of occurrence of 4 week wet spell was high during SMW 25 - 34when it ranges between 62 -83%. It was highest during SMW 31 when the probability was 83%.

Crop planning

Rainfall is unimodal in the district and we are having around 21 - 25 weeks LGP.Hence, intercropping and sequential cropping can be taken in most of the blocks and double cropping in some of the blocks wherever irrigation facility either as groundwater or surface is available. The two crops should be having different rooting depth and volume and if possible, their water requirement should be also different. This will help to avoid water and nutrient competition and crop will give high yield. Example - Arhar + Rice (2:5), Arhar + Groundnut (2:6).

Result presented in Table 2 shows that the probability of getting 20mm rainfall or more is high between SMW 25 to 38, hence crop can be planned during this period considering the information contained in block weather advisory. Sundergarh comes under moist sub-humid climate where humid period is more than 12 weeks duration and the rainfall is twice that of PET. Hence, paddy based cropping system is suitable on lowlands as the district receives good monsoon rainfall which is sufficient for the paddy during kharif season where other crops could not withstand water stagnation. Medium duration rice varieties can easily be grown with little fear of drought at reproductive stage. Moreover, the residual soil moisture after the harvest of rice can be effectively utilised for raising another short duration crop like lentil, mustard, greengram and biri in winter.

Length of growing period can vary depending upon the soil type and slope, which together affects the soil depth and hence soil's water holding capacity. Thus under the same rainfall conditions, a block can support either intercropping or sequence cropping or double cropping (short duration second crop) depending on the soil characteristics, if assured irrigation facilities are available.

Taking into consideration the length of growing period and the irrigation potential, double cropping can be taken in blocks like Sundergarh, Lephripara, Hemgir, Rajgangpur, Kutra, Lathikata, Bargaon, Tangarpali and, if assured irrigation facilities are available. The first two blocks (Sundergarh and Lephripara) are having 170 days of LGP with sufficient irrigation facility. In remaining six blocks **(**Rajgangpur, Kutra, Lathikata, Bargaon, Tangarpali and Hemgir), LGP is only 160 – 170 days but their percent irrigated area is high during rabi season, thus it can meet out crop water requirement during water stress periods. Bonai and Subdega are having LGP of 165 days but percent irrigated area during rabi is <35% in these blocks. Hence second crop should be taken only if one has irrigation source that too with great care.

Since the probability of occurrence of wet week with 10mm as the threshold is more than 45% from week 21 and average weekly rainfall ranges from11.5 mm to 34.4 mm during SMW 21-24, the pre-monsoon rain can be utilized for summer ploughing and seed bed preparations. Land preparation and sowing operations can be done during week 22 to 24 because P(w/w) with 20 mm as the threshold during this period and in subsequent weeks is more than 60%. Sowing operations performed in week 23 favours good germination of seeds and also helps in avoiding moisture stress for germination period during 24 –26 SMW. In the event of delayed onset of rainy season, the sowing operations can be taken up latest by 27 SMW (2–8 July) and further delay in sowing may cause very low productivity and even crop failure.

Table 2.Expected weekly rainfall at 90%, 75% and 50% probability levels

Station: Sundergarh						
	Precipitation (mm) for the probabilities					

Week	90%	75%	50%	25%	10%	Mean(mm)
1	0.3	0.8	2.3	5.0	8.7	2.6
2	0.2	0.9	2.7	6.2	11.2	3.5
3	0.2	0.7	1.9	3.9	6.7	1.8
4	0.1	0.8	3.3	9.0	18.0	5.8
5	0.3	0.9	2.2	4.5	7.5	2.2
6	0.0	0.0	1.5	5.1	7.6	1.5
7	0.0	0.0	4.5	14.2	21.9	4.5
8	0.0	0.1	1.5	4.9	7.1	1.5
9	0.2	0.9	2.7	6.4	11.6	3.6
10	0.3	1.0	2.7	5.6	9.6	3.0
11	0.5	1.1	2.2	3.7	5.7	1.7
12	0.4	0.8	1.5	2.5	3.8	0.9
13	0.4	1.0	2.0	3.6	5.7	1.6
14	0.6	1.3	2.7	4.8	7.5	2.5
15	0.4	1.1	2.7	5.4	9.0	2.9
16	0.4	1.2	2.8	5.5	9.2	3.0
17	0.5	1.2	2.8	5.2	8.4	2.8
18	1.1	2.5	5.1	9.1	14.2	5.6
19	0.5	1.6	4.5	9.8	17.2	6.1
20	0.7	2.3	6.0	12.7	21.7	8.1
21	0.9	2.9	8.0	17.3	30.0	11.5
22	1.5	4.0	9.5	19.0	31.5	12.7
23	2.8	7.0	15.5	29.5	47.4	20.3
24	3.3	9.5	23.8	49.0	82.9	34.4
25	10.6	25.1	54.3	101.1	160.8	72.2
26	14.3	29.0	55.4	94.7	142.8	68.4
27	20.4	34.8	57.9	89.7	126.5	66.3
28	33.4	48.6	70.6	98.4	128.8	76.0
29	33.7	54.7	87.3	131.0	180.8	98.4
30	23.5	41.0	69.6	109.4	155.8	80.7
31	35.7	54.9	83.6	121.0	162.7	92.0
32	29.2	47.4	75.8	113.9	157.3	85.4
33	37.4	51.6	71.4	95.8	121.9	75.4
34	26.6	41.7	64.6	94.8	128.7	71.5
35	22.7	36.7	58.1	86.8	119.4	65.0
36	22.6	36.3	57.3	85.4	117.3	64.0
37	17.7	29.6	48.4	74.0	103.5	54.8
38	11.1	22.0	41.4	70.2	105.1	50.5
39	4.4	9.7	20.0	35.9	55.8	25.1
40	1.8	5.7	15.2	32.3	55.7	22.3
41	0.8	2.9	8.8	20.0	35.9	13.5
42	0.5	2.3	8.1	20.2	38.2	13.8
43	0.3	1.4	5.8	15.9	31.5	10.8
44	0.4	1.5	5.0	12.3	22.9	8.0
45	0.1	0.7	2.5	6.5	12.4	3.8
46	0.3	0.8	2.0	4.3	7.3	2.1
47	0.4	0.7	1.3	2.0	2.9	0.5
48	0.1	0.5	1.9	4.9	9.5	2.6
49	0.2	0.6	1.8	4.2	7.7	2.1
50	0.3	0.7	1.7	3.2	5.3	1.3
51	0.2	0.7	1.8	3.8	6.4	1.7

Table 3. Initial and Conditional Probability of Rainfall

INITIAL AND CONDITIONAL PROBABILITIES OF RAINFALL						
(Markov chain probability)						
Station : Sundergarh						
Period : 1995-2017			Limit : 20 mm			
	INITIAL PROBABILITY		CONDITIONAL PROBABILITY			
WEEK	P(W)	P(D)	P(W/W)	P(D/W)	P(D/D)	P(W/D)
1	0.0455	0.9545	0.0000	0.0000	0.9545	0.0455
2	0.0435	0.9565	0.0000	1.0000	0.9545	0.0455
3	0.0435	0.9565	0.0000	1.0000	0.9545	0.0455
4	0.0435	0.9565	1.0000	0.0000	1.0000	0.0000
5	0.0435	0.9565	0.0000	1.0000	0.9545	0.0455
6	0.0000	1.0000	0.0000	1.0000	1.0000	0.0000
7	0.0435	0.9565	0.0000	0.0000	0.9565	0.0435
8	0.0000	1.0000	0.0000	1.0000	1.0000	0.0000
9	0.0435	0.9565	0.0000	0.0000	0.9565	0.0435
10	0.0435	0.9565	0.0000	1.0000	0.9545	0.0455
11	0.0000	1.0000	0.0000	1.0000	1.0000	0.0000
12	0.0000	1.0000	0.0000	0.0000	1.0000	0.0000
13	0.0000	1.0000	0.0000	0.0000	1.0000	0.0000
14	0.0000	1.0000	0.0000	0.0000	1.0000	0.0000
15	0.0435	0.9565	0.0000	0.0000	0.9565	0.0435
16	0.0000	1.0000	0.0000	1.0000	1.0000	0.0000
17	0.0000	1.0000	0.0000	0.0000	1.0000	0.0000
18	0.0000	1.0000	0.0000	0.0000	1.0000	0.0000
19	0.1304	0.8696	0.0000	0.0000	0.8696	0.1304
20	0.0870	0.9130	0.6667	0.3333	1.0000	0.0000
21	0.0870	0.9130	0.0000	1.0000	0.9048	0.0952
22	0.2174	0.7826	1.0000	0.0000	0.8571	0.1429
23	0.4348	0.5652	0.6000	0.4000	0.6111	0.3889
24	0.6087	0.3913	0.7000	0.3000	0.4615	0.5385
25	0.7826	0.2174	0.7857	0.2143	0.2222	0.7778
26	0.9130	0.0870	0.8889	0.1111	0.0000	1.0000
27	0.9565	0.0435	0.9524	0.0476	0.0000	1.0000
28	0.9565	0.0435	0.9545	0.0455	0.0000	1.0000
29	0.9565	0.0435	0.9545	0.0455	0.0000	1.0000
30	0.8696	0.1304	0.8636	0.1364	0.0000	1.0000
31	1.0000	0.0000	1.0000	0.0000	0.0000	1.0000
32	0.9130	0.0870	0.9130	0.0870	0.0000	0.0000
33	0.9565	0.0435	0.9524	0.0476	0.0000	1.0000
34	0.9565	0.0435	0.9545	0.0455	0.0000	1.0000
35	0.9130	0.0870	0.9091	0.0909	0.0000	1.0000
36	0.9130	0.0870	0.9048	0.0952	0.0000	1.0000
37	0.9130	0.0870	0.9048	0.0952	0.0000	1.0000
38	0.7391	0.2609	0.7619	0.2381	0.5000	0.5000
39	0.6087	0.3913	0.5294	0.4706	0.1667	0.8333
40	0.4348	0.5652	0.5000	0.5000	0.6667	0.3333
41	0.1739	0.8261	0.2000	0.8000	0.8462	0.1538
42	0.1739	0.8261	0.0000	1.0000	0.7895	0.2105
43	0.1739	0.8261	0.2500	0.7500	0.8421	0.1579
44	0.1304	0.8696	0.2500	0.7500	0.8947	0.1053
45	0.0435	0.9565	0.0000	1.0000	0.9500	0.0500
46	0.0435	0.9565	0.0000	1.0000	0.9545	0.0455
47	0.0000	1.0000	0.0000	1.0000	1.0000	0.0000
48	0.0435	0.9565	0.0000	0.0000	0.9565	0.0435
49	0.0435	0.9565	0.0000	1.0000	0.9545	0.0455
50	0.0435	0.9565	0.0000	1.0000	0.9545	0.0455
51	0.0435	0.9565	0.0000	1.0000	0.9545	0.0455

Table 4. Probability of occurrence of dry and wet spell in consecutive weeks

Probabilities of Dry and Wet Spells of Consecutive Weeks						
(Markov chain probability)						
Period : 1995-2017			Limit : 20 mm			
	Consecutive Dry Probability			Consecutive Wet Probability		
	----------			----------		
Week	2D	3D	4D	2W	3W	4W
1	0.9112	0.8697	0.8697	0.0000	0.0000	0.0000
2	0.9130	0.9130	0.8715	0.0000	0.0000	0.0000
3	0.9565	0.9130	0.9130	0.0435	0.0000	0.0000
4	0.9130	0.9130	0.8733	0.0000	0.0000	0.0000
5	0.9565	0.9149	0.9149	0.0000	0.0000	0.0000
6	0.9565	0.9565	0.9149	0.0000	0.0000	0.0000
7	0.9565	0.9149	0.8733	0.0000	0.0000	0.0000
8	0.9565	0.9130	0.9130	0.0000	0.0000	0.0000
9	0.9130	0.9130	0.9130	0.0000	0.0000	0.0000
10	0.9565	0.9565	0.9565	0.0000	0.0000	0.0000
11	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000
12	1.0000	1.0000	0.9565	0.0000	0.0000	0.0000
13	1.0000	0.9565	0.9565	0.0000	0.0000	0.0000
14	0.9565	0.9565	0.9565	0.0000	0.0000	0.0000
15	0.9565	0.9565	0.9565	0.0000	0.0000	0.0000
16	1.0000	1.0000	0.8696	0.0000	0.0000	0.0000
17	1.0000	0.8696	0.8696	0.0000	0.0000	0.0000
18	0.8696	0.8696	0.7867	0.0000	0.0000	0.0000
19	0.8696	0.7867	0.6744	0.0870	0.0000	0.0000
20	0.8261	0.7081	0.4327	0.0000	0.0000	0.0000
21	0.7826	0.4783	0.2207	0.0870	0.0522	0.0365
22	0.4783	0.2207	0.0491	0.1304	0.0913	0.0717
23	0.2609	0.0580	0.0000	0.3043	0.2391	0.2126
24	0.0870	0.0000	0.0000	0.4783	0.4251	0.4049
25	0.0000	0.0000	0.0000	0.6957	0.6625	0.6324
26	0.0000	0.0000	0.0000	0.8696	0.8300	0.7923
27	0.0000	0.0000	0.0000	0.9130	0.8715	0.7527
28	0.0000	0.0000	0.0000	0.9130	0.7885	0.7885
29	0.0000	0.0000	0.0000	0.8261	0.8261	0.7543
30	0.0000	0.0000	0.0000	0.8696	0.7940	0.7561
31	0.0000	0.0000	0.0000	0.9130	0.8696	0.8300
32	0.0000	0.0000	0.0000	0.8696	0.8300	0.7546
33	0.0000	0.0000	0.0000	0.9130	0.8300	0.7510
34	0.0000	0.0000	0.0000	0.8696	0.7867	0.7118
35	0.0000	0.0000	0.0000	0.8261	0.7474	0.5695
36	0.0000	0.0000	0.0000	0.8261	0.6294	0.3332
37	0.0435	0.0072	0.0048	0.6957	0.3683	0.1841
38	0.0435	0.0290	0.0245	0.3913	0.1957	0.0391
39	0.2609	0.2207	0.1743	0.3043	0.0609	0.0000
40	0.4783	0.3776	0.3180	0.0870	0.0000	0.0000
41	0.6522	0.5492	0.4914	0.0000	0.0000	0.0000
42	0.6957	0.6224	0.5913	0.0435	0.0109	0.0000
43	0.7391	0.7022	0.6703	0.0435	0.0000	0.0000
44	0.8261	0.7885	0.7885	0.0000	0.0000	0.0000
45	0.9130	0.9130	0.8733	0.0000	0.0000	0.0000
46	0.9565	0.9149	0.8733	0.0000	0.0000	0.0000
47	0.9565	0.9130	0.8715	0.0000	0.0000	0.0000
48	0.9130	0.8715	0.8319	0.0000	0.0000	0.0000
49	0.9130	0.8715	0.8715	0.0000	0.0000	0.0000
50	0.9130	0.9130	0.0000	0.0000	0.0000	0.0000
51	0.9565	0.0000	0.0000	0.0000	0.0000	0.0000

CONCLUSION

The long-term mean annual rainfall of Sundergarh district is 1273 mm with variability ranging between 19.48 – 33.61% for different blocks and on an average 61 rainy days. The district receives around 86.8% of its annual rainfall during SW monsoon. During monsoon, probability of consecutive wet for 2 weeks gradually increased and was >50% at 20mm limit during 25 to 37 SMW in different blocks. Again after 37th SMW, it progressively decreased. Hence sufficient rain is available for plant growth during this period. Rice is the dominant crop grown in the region. This study further shows that irrigation scheduling is required between 1st and 19th SMW and during 38 week to 52 week for growing short duration summer and winter crops. However supplementary irrigation and moisture conservation need to be available if the crop is of long duration. Present study helps to adjust crop, cropping system in changing climate and irrigation scheduling of different crops to have efficient use of rainwater in rainfed areas.

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