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Rainfall probability analysis for contingent crop planning in Jagatsinghpur (Odisha)

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Abstract
Rainfall is the most important but variable climatic parameter in suitable crop planning especially in the regions of rainfed agriculture. Rainfall data of 20 years (1995-2014) of Jagatsinghpur district were analysed whose annual average rainfall is 1495.3 mm, with 81 numbers of rainy days, to find out the weekly, monthly and seasonal probability. During monsoon (Jun–September) 1077.9mm (74.6%), post monsoon (October-November) winter (December-February) and summer (March-May) received about 223.5 mm (15.4%), 12.7 mm (0.8%), 120.7 mm (8.0%), rainfall. It has been found that 75 per cent assured probability level rainfall of more than 250 mm can be expected only in July and August months and this rainfall is hardly sufficient for meeting the water requirement in upland situations. However at 50 per cent probability which is equivalent to average condition, cultivation of rice is possible under well water management conditions or else some non- rice crops can be taken as an alternative. On seasonal basis rainfall at assured probability level of 75 per cent is sufficient as the quantity is 850.1 mm rainfall in monsoon season. The Risk proof crop which can be best suitable for *Kharif* season are rice for medium and low land and non-paddya crops like groundnut pulses soybean can be taken. During winter season pulses like black gram, green gram and oil seeds like sesame, groundnut can be taken. Taking the predicated rainfall of around more than 60 mm during summer fibre crop like jute can be grown in Jagatsinghpur.

Keywords: Rainfed agriculture, seasonal probability, variable climatic parameter

Introduction
Rainfall is one of the most important natural input resources to crop production and its occurrence and distribution is erratic, temporal and spatial variations in nature. Of all the climatic factors, rainfall is of the greatest concern to population in rainfed agriculture. Around 60 per cent of the Indian agriculture is rain-dependent, distress-prone and vulnerable to climate. The rainfed agro-ecology is characterized as vulnerable for agricultural operations which revolve around moisture availability due to rainfall pattern, amount, intensity and its uses for crop production (Deka and Nath, 2000) [3]. Detailed knowledge of rainfall pattern helps in planning the cultivation of crops, their varieties, adoption of cultural operations, designing of different storage structures (Ray *et al*., 1987) and harvesting of excess rain water of any region (Sinhababu 1977; Budhar *et al.,* 1987 and Kar, 2002) [10, 5] to meet outirrigation requirement during drought period. Probability analysis can be used for prediction of occurrence of future events from available records of rainfall with the help of statistical methods (Kumar and Kumar, 1989) [6]. Therefore, probability analysis of rainfall is necessary for solving various water management problems and to access the crop failure due to deficit or excess rainfall. Scientific prediction of rains and crop planning done analytically may prove a significant tool in the hands of farmers for better economic returns (Bhakar *et al.,* 2008) [2]. Generally, the cropping pattern is suggested considering the rainfall probabilities at different levels (Mahale and Dhane, 2003). Probability and frequency analysis of rainfall data enables us to determine the expected rainfall at various chances. Studies on rainfall probability in India have also been carried out earlier by many workers (Victor *et al.,* 1991 and Panigrahi, 1998) [7]. Rainfall at 80 per cent probability can be safely taken as assured rainfall, while 50 per cent chance can be considered as the maximum limit for taking any risk (Bhakar *et al.,* 2008) [2]. The weekly distribution of rainfall and its probability is helpful in crop planning by identifying the period of drought, normal and excess rainfall (Ray *et al.,* 1980) [9]. In most of studies the workers have suggested the cropping pattern considering the rainfall amount at different probability levels (Hundal and Kaur, 2002; Ahmed *et al.,* 2009 and Ravindrababu *et al.,* 2010)

[4, 1, 8]. Kulandaivelu (1984) analysed the daily precipitation data of Coimbatore for a period of 70 years for weekly totals by fitting incomplete Gamma distribution model. The data indicate the likely commencement of rains, period of drought length of growing season and end of growing season. Based on the assured rainfall at (50%) probability level, suitable cropping system was suggested for Coimbatore. Weekly rainfall analysis is very much important for crop planning and analyzing the probability of occurrence of dry and wet periods. This will act as bench mark for crop planning as well as sustainable agricultural management. This analysis can be helpful to find out different cropping system including intercropping and sequence cropping suitable during that period.

In Odisha average annual rainfall is 1452 mm, there are large variations in annual rainfall and these variations often result in reduced crop productivity especially rice crop. Terminal drought is a recurring feature for rice crop in this region. Also intermittent dry spells make the crop operations delayed as 80 per cent of the area in this region is under rainfed conditions. Thus, the success of rice crop depends upon not only the monsoonal rainfall but also on the October rainfall which occurs due to cyclonic activity in the Bay of Bengal. Hence, an attempt has been taken in the present study for rainfall probability analysis of coastal districts of Jagatsinghpur Odisha, which come under East and South Eastern Coastal Plain agroclimatic zone of Odisha, having a broad soil groups namely Saline, Lateritic, Alluvial, Red & Mixed red & Black soils. Here the prevailing climatic condition is Hot and humid.

Materials and Methods

The Study Area

Jagatsinghpur district is one of the coastal districts of Odisha and lies between 19^0 58' and 20^0 23' N. latitude and between 86^0 30' and 86^0 45' E. longitudes. The district is surrounded by the Bay of Bengal in the east, Kendrapara district in the north, Cuttack district in the west and Puri district in the south. The area of the district is 1,668 sq. kilometers. Comprising of 8 block Namely, Biridi, Balikuda, Erasama, jagatsinghpur, Kujanga, Nuagaon, Raghunathpur, Tritol as shown in Fig. 1

Fig 1: Block Boundary map of Jagatsinghpur district

It is situated in the Agro Climatic Zone of East and south eastern coastal plain zone. Net cultivated area 104 thousand hectare, total rainfed area 38.1 thousand hectare. Soil type of jagatsinghpur Laterite Soils, Deep Alluvial soils, Coastal saline soils. Normal rainfall 1514.6 mm and rainy days 65.5(Number). The Major food crop grown in Jagatsinghpur District is paddy sugarcane, turmeric, jute, chilli during Kharif sesamum, green gram, black gram groundnut, and horsegram during rabi season are the major commercial crops. The District enjoys rich fertile soil of the Mahanadi. The maximum temperature of the District is 38^0 C and minimum temperature is 12^0 C.

Rainfall Probability

The probability of rainfall enable us to determine the expected rainfall at various chances. Twenty years of rainfall data Puri district of Odisha collected from Special Relief Commissioner (SRC), Government of Odisha, are used to find out seasonal, monthly and weekly rainfall probability. It is estimated for each district separately using WEATHER COCK software which is developed by CRIDA, Hyderabad for weather data analysis. Weather Cock contain 26 nos. of modules which are related to agroclimatic parameters out of which 8 to 10 modules were used in this study for weather data analysis. Some attention to be made before going for weather data analysis by using Weather Cock software are as follows:

1. NEVER rename the Weather Cock folder.
2. All Data files are should be either created in Notepad or as csv file (comma separated values) of excel.
3. Kindly examine the data file structure in the SAMPLE DATA folder for any analysis before creating the new data file.
4. While analysing data with.csv file if any error occurs then open the.csv file in Notepad and delete all the last commas in every data line.
5. Data for every day Date structure- mm/dd/yyyy.
6. The possible errors in data are like 12.8.0 or 12..8 or 12.8.instead of 12.8.Data may be typed as a non-numeric symbols (space, _, +).

Correct Data File
Bhubaneswar
Year, Week, RF (MM)
2016, 1, 0
2016, 2, 0
In Correct Data File
Bhubaneswar

Year, Week, RF (MM),
1971, 1, 0,
The outline deals with research method and procedures are as follows.

Analysis of Annual and Weekly Rainfall Probability

Annual and Weekly rainfall probabilities were calculated through the module named as "incomplete Gamma Probabilities. exe". Block wise weekly rainfall data is used as an input to obtain the annual and weekly probability of rainfall at a level of 90%, 75%, and 50%. The amount of rainfall at three probability level has been computed for each standard week by fitting Incomplete Gamma Distribution model.

Analysis of Monthly Probability

Monthly rainfall probability is calculated through the module named as "Incomplete Gamma Probabilities.exe". Rainfall data of twelve months of the three districts are used as inputs for determining monthly probability of rainfall at a level of 90%, 75% and 50%. The amount of rainfall at three probability level has been computed for each standard month by fitting Incomplete Gamma Distribution model.

Analysis of Seasonal Probability

Seasonal rainfall data of the three districts are used as input to determine seasonal probability of rainfall of each districts. It is calculated through the module named as "Incomplete Gamma Probabilities.exe". The whole year was categorised into four major season namely Monsoon, Post-monsoon, summer and winter according to the Odisha condition. Monsoon season consist of four months namely June, July, August and September. Post-monsoon consist of two months namely October and November. Likewise December, January and February are under winter season and March, April and May are under summer season.

Result

Table 1: Annual and Weekly Rainfall Probability

Week	Probability			
	90%	75%	50%	Mean(mm)
1	0.4	0.8	1.7	1.2
2	0.3	0.8	1.9	1.8
3	0.3	0.7	1.6	1.2
4	0.4	0.8	1.5	0.9
5	0.2	0.7	1.7	1.4
6	0.0	0.0	1.9	1.9
7	0.0	0.0	3.6	3.6
8	0.0	0.3	1.9	1.9
9	0.6	0.9	1.4	0.5
10	0.4	0.7	1.4	0.7
11	0.1	0.7	2.9	4.7
12	0.4	0.8	1.5	0.9
13	0.8	0.9	1.1	0.1
14	0.1	0.8	4.2	9.3
15	0.3	0.8	2.0	1.8
16	0.3	1.0	2.6	3.1
17	0.2	1.0	3.6	5.5
18	0.5	1.7	4.6	6.0
19	0.3	2.5	12.0	27.1
20	0.3	2.1	10.7	24.3
21	1.2	5.3	18.8	34.0
22	0.9	3.5	11.2	18.5
23	2.1	6.4	16.4	23.8
24	1.0	5.2	20.3	39.2
25	10.4	19.4	34.5	40.6
26	13.3	25.3	46.2	55.3
27	14.3	30.4	60.3	76.3
28	8.7	16.9	31.6	37.9
29	15.5	33.5	67.7	86.6
30	17.4	30.1	50.4	57.9
31	17.3	39.6	83.3	109.4
32	19.0	34.4	60.1	70.7
33	24.8	40.1	63.9	71.6
34	15.5	31.2	59.3	73.1
35	16.7	34.7	67.8	84.9
36	19.2	35.8	64.0	76.3
37	4.7	14.5	38.2	57.3
38	11.9	26.1	53.3	68.4
39	2.9	9.4	26.1	40.2
40	5.2	15.9	41.8	62.7
41	1.6	7.3	25.5	46.1
42	0.2	2.3	13.5	35.0
43	0.3	2.6	13.9	34.0
44	0.2	1.3	6.2	12.9
45	0.2	1.7	7.8	16.8
46	0.1	0.6	3.9	10.2
47	0.2	0.7	1.9	2.0
48	0.0	0.0	0.0	0.0
49	0.2	0.6	1.6	1.6
50	0.2	0.6	1.6	1.6
51	0.3	0.7	1.3	0.7
52	0.5	0.7	0.9	0.0
Annual	1041.5	1210.7	1419.5	1443.5

The total annual predicted rainfall of the district at 90%, 75% and 50% probability are 1041.5 mm, 1210.7 mm and 1419.5 mm respectively. At 75% probability the district received very less rainfall (<6mm) before the onset of monsoon that is before 24th Standard Meteorological Weak (SMW). But at the beginning of monsoon in SWM 25, 26 and 27 the district may receive a fair amount of rainfall. After SMW 28 a very good amount of rainfall may be received up to SMW 38 and decreased thereafter upto 40th week that is the cessation of monsoon. All SMW between 27 to 38 is expected to get rainfall above 30 mm. at 75% probability where was from SMW 25th week 40th week at 50% probability. In SMW 33 the districts may receive highest rainfall of 40.1 mm. On the other hand, SMW 6, 7 may not receive no rainfall. The SMW 31 is probable to receive highest rainfall in all the three level of probabilities (90%, 75% and 50%).

Table 2: Monthly Rainfall Probability

Month	Probability			
	90%	75%	50%	Mean(mm)
January	0.3	1.2	3.8	5.6
February	0.4	1.8	6.2	10.0
March	0.1	0.9	5.6	15.0
April	0.6	2.8	10.6	19.6
May	23.1	47.7	92.6	116.1
June	61.7	97.9	153.3	171.8
July	128.0	176.3	243.3	259.0
August	202.4	279.0	385.2	410.7
September	98.0	149.8	227.1	251.2
October	26.6	62.6	134.8	180.2
November	0.6	4.5	21.3	47.8
December	0.0	0.5	5.8	24.4

Maximum amount of rainfall is expected in three months of the year, namely July, August and September with more than 150 mm rainfall at 75% probability (Table 4.16). Highest rainfall of 279.0 mm is predicted in the month of August. The period of six months from November to April the district may get negligible amount of rainfall (below 5 mm). About 813.3 mm is received in rest six month period from May to October.

Table 3: Seasonal Rainfall Probability

Season	Probability		
	90%	75%	50%
Monsoon	699.8	850.1	1041.2
Post monsoon	26.0	74.5	185.9
summer	36.7	68.9	124.1
Winter	0.8	3.8	14.0

Seasonal probability was calculated based on rainfall data of the districts for four seasons namely monsoon (SMW 23 to 39), post monsoon (SMW 40 to 48), winter (SMW 49 to 52 and 1 to 8) and summer (SMW 9 to 22). At 75% probability during monsoon may receive highest of rainfall amount of 850.1, post monsoon 74.5, in summer 68.9, in winter 3.8mm.

Discussion

At 75% probability level during monsoon season Jagatsinghpur district received about 850.1 mm rainfall. It is distributed, with the period from 25th to 40th weeks giving rise to or length of growing season 120 days or 17 weeks. So the non-paddy crops like groundnut, sunflower, short duration arhar of 120 days can be taken is upland during kharif season. The rainfall at 75% assured level should be utilized for growing rainy-season crops like maize, cowpea, groundnut, black gram and direct-seeded rice in second fortnight of June with the commencement of monsoon. Senapati *et al*. (2009), revealed that the duration of monsoon period is 92 days and short duration crops of 90 - 95 days should be preferred to be grown in rainfed uplahds. In medium land rice can be taken with a duration of maximum upto 130 days or short duration rice of 100 to 120 days can be taken to accommodate vegetables like cole crops as a second crops, sowing of which can be made early to best utilize the soil moisture. In low land, long duration rice of 150 days may be grown as the altitude of the coastal district like Jagatsinghpur is low.

Conclusion

At 75% probability level during monsoon season Jagatsinghpur district received about 850.1 mm rainfall. It is distributed, with the period from 25th to 40th weeks giving rise to or length of growing season 120 days or 17 weeks. So the non-paddy crops like groundnut, sunflower, short duration arhar of 120 days can be taken is upland during kharif season. During the winter season (40th week onwards), negligible rainfall is recorded at 75% probability level. So the surface soil would become dry with rare chances of getting adequate soil-moisture in the seeding zone. Hence, it was also revealed that the rabi crops have to be raised under moisture stress conditions. The crops should be able to use residual soil profile. During summer season both district likely to get 68.9 and 61.6 mm rainfall at 75% probability so that cash crop like jute can be taken in low land during April that is on 17th week onwards and will be harvested within 30 to 31 week so that rice crop of medium duration can be taken as second crop.

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