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Analysis of rainfall probability for strategic crop planning in Puri district of Odisha

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Abstract

The rainfall data of costal district Puri for 20 years (1995-2014) were collected from Special Relief Commissioner (SRC), Government of Odisha, Bhubaneswar were analyzed by using the method of incomplete gamma probability, to estimate annual, seasonal, monthly and weekly rainfall probability. The data revealed that the average rainfall during last 20 year of Puri district 1449.3mm. During monsoon (Jun–September) Puri 1109.9 mm rainfall which contribution about 74.2 annual rainfall. During post monsoon (October–November) winter (December–February) and summer (March–May) Puri received about 251.7 mm (16.8%), 12.7 mm (0.8%), 120.7 mm (8.0%) rainfall. Highest rainfall was receiving in the month of August 382.4mm in Puri District. The total annual predicted rainfall of the district at 90%, 75% and 50% probability are 1052.1 mm, 1236.9 mm and 1466.8 mm respectively. At 75% probability the district received very less rainfall (<5mm) before the onset of monsoon that is before 24th Standard Meteorological Weak (SMW). But at the beginning of monsoon in SWM 24, 25 and 26 the district may receive a fair amount of rainfall. After SMW 28th a very good amount of rainfall may be received up to SMW 38th and decreased thereafter upto 41th week that is the cessation of monsoon. All SMW between 25 to 38th is expected to get rainfall above 30 mm rainfall. At 75% probability where was from SMW 25th week 40th week at 50% probability. The Risk proof crop which can be best suitable for *Kharif* season are rice in puri, medium and low land and non paddy 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.

Keywords: crop planning, incomplete gamma probability, rainfall probability and special relief commissioner (SRC)

Introduction

Rainfall is the single most important factor in crop production programme, of all the climatic factors, rainfall is of greatest concern to population in rainfed agriculture. The variation of monsoonal and annual rainfall in space and time are well known and this inter-annual variability of monsoonal rainfall has considerable impact on agricultural production, water management and energy generation. Analysis of annual, seasonal and monthly rainfall of a region is useful to design water harvesting structure. Similarly weekly rainfall analysis give more useful information in crop planning (Sharma *et al.*, 1979) [9]. There have been different techniques for determining probability distribution on rainfall analysis and best fit probability distribution function such as normal, log-normal, gumbel, weibull and Pearson type distribution have been identified as per different research studies.

Rainfall analyses are helpful for proper crop planning under changing environment in any region. Therefore, in this paper, an attempt has been made to analyze 20 years of rainfall (1995–2014) in and Puri district in Odisha, for prediction using in-complete gamma distribution were the best-fit probability distribution. The earliest and most delayed week of the onset of rainy season was the 20th standard meteorological week (SMW) (14th–20th May) and 25th SMW (18th–24th June), respectively. Similarly, the earliest and most delayed week of withdrawal of rainfall was the 39th SMW (24th–30th September) and 47th SMW (19th–25th November), respectively. The longest and shortest length of rainy season was 26 and 17 weeks, respectively.

In Odisha coastal line of 482 Km is exposed to frequent flood and water logging in most of the years. Apart from heavy rainfall, cyclonic wind along with heavy rainfall and tidal flows also cause flood in coastline. Flood remains for about 5-15 days in many parts of coastal belts

along with damage of life and properties and also crop fields affecting food security of the victims. Due to cyclone, the state has experienced severe damage of crop in coastal areas. Hence crop planning would certainly result in reducing the crop loss and productivity in the event of cyclone / flood and it forms the core component of prevention strategy. Advanced crop management interventions and moisture conservation techniques should form the main component and they should be adopted by the farmers on large scale to sustain the cultivated land utilization index with minimum risk.

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 Puri districts of 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

1. The study area

Puri, one of the coastal districts of Orissa, Considering the geographical location, the district Puri is situated between $19^{\circ} 28'$ and $20^{\circ} 10'$ north latitude and $86^{\circ} 9'$ and $86^{\circ} 25'$ east longitude. It is surrounded by the district Cuttack and Jagatsinghapur in its north, Khordha in its west, Ganjam to the southwest and the Bay of Bengal to its east and southeast. The district is having an area of 3479 sq. kms and occupies the 21st rank among the 30 districts of the state. Comprising of 11 block Namely, Astarang, Brahmagiri, Delang, Gop, Kakatpur, kanas, Krushnaprasad, Nimapada, Pipli, Puri, Satyabadi as shown in Fig.



Fig 1: Block Boundary map of Puri district (Source: mapsofindia.com)

It is situated in the Agro Climatic Zone of East and South Eastern Coastal Plain Zone. Net cultivated area is 189 thousand hectare, total rainfed area 40.1 thousand hectare. Soil type of Puri Alluvial Soil, Laterite Soil, Acidic Soil. Normal rainfall 1408.6 mm and rainy days 62.3 (Number). The minimum temperature of the District is 22 approximately 16. 45 degrees Celsius and the maximum 33. 9 degrees Celsius. Paddy, wheat, mung, biri, kulthi and groundnut are some of the major crops grown in the District.

2. 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.

3. 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.

4. 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.

5. 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.

Results and Discussion**1. Annual and weekly rainfall probability**

The total annual predicted rainfall of the district at 90%, 75% and 50% probability are 1052.1 mm, 1236.9 mm and 1466.8 mm respectively (Table 4.14) At 75% probability the district received very less rainfall (<5mm) before the onset of monsoon that is before 24th Standard Meteorological Week (SMW). But at the beginning of monsoon in SWM 24, 25 and 26 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 41th week that is the cessation of monsoon. All SMW between 25 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 31 the 45 districts may received highest rainfall of 53.4 mm. On the other hand, SMW 6, 7 and 9 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 1: Annual and weekly rainfall probability of puri

Week	Probability			
	90%	75%	50%	Mean(mm)
1	0.5	0.7	0.9	0.0
2	0.7	0.9	1.1	0.2
3	0.3	0.7	1.5	1.1
4	0.4	0.8	1.6	1.1
5	0.4	0.8	1.4	0.7
6	0.0	0.0	3.2	3.2
7	0.0	0.0	3.6	3.6
8	0.0	0.0	2.8	2.8
9	0.2	0.6	1.8	1.9
10	0.4	0.9	2.0	1.7
11	0.3	1.0	3.2	4.5
12	0.2	0.7	2.2	2.7
13	0.3	0.7	1.6	1.3
14	0.1	0.7	3.0	5.4
15	0.2	0.7	1.9	1.9
16	0.3	1.0	2.7	3.1
17	0.2	1.1	3.7	5.9
18	0.3	1.2	3.6	4.9
19	0.2	2.0	12.6	33.9
20	0.2	1.9	10.2	24.1
21	0.8	3.7	13.8	25.5
22	0.8	2.5	6.3	8.4
23	1.5	5.7	17.3	28.0
24	1.1	5.2	18.0	32.3
25	8.8	17.9	34.4	42.3
26	10.8	23.8	48.6	62.3
27	7.0	21.5	56.5	85.2
28	7.0	17.0	37.4	50.0
29	16.4	32.6	61.2	75.0
30	20.9	34.4	55.6	62.6
31	33.0	53.4	85.1	95.7
32	19.2	38.6	73.4	90.6
33	19.9	35.2	60.3	70.3
34	15.9	31.4	58.8	71.8
35	18.3	38.2	74.9	94.3
36	20.7	35.1	58.2	66.5
37	9.3	21.9	47.5	63.0
38	17.5	31.8	55.8	65.6
39	3.6	11.7	32.4	50.1
40	7.3	19.1	44.7	62.4
41	0.9	5.0	20.4	40.7
42	1.1	5.6	21.4	41.4
43	0.3	2.8	14.5	34.7
44	0.2	2.2	12.9	33.6
45	0.3	2.2	10.3	22.7
46	0.1	0.9	3.9	7.7
47	0.3	0.7	1.6	1.2
48	0.5	0.7	0.9	0.0
49	0.1	0.6	2.1	3.0
50	0.1	0.6	2.1	2.9
51	0.2	0.6	1.5	1.2
52	0.6	0.8	1.1	0.2
Annual	1052.1	1236.9	1466.8	1495.3

2. Seasonal rainfall probability

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 season may receive highest of rainfall amount 894.7 mm and winter season may receive lowest rainfall amount 2.6mm.

Table 2: Seasonal rainfall probability

Season	Probability		
	90%	75%	50%
Monsoon	747.4	894.7	1080.2
Post monsoon	24.1	74.4	196.5
summer	17.5	44.1	100.3
Winter	0.4	2.6	12.6

3. Monthly rainfall probability

The monthly probability of rainfall is calculated Puri district separately at 90%, 75% and 50% probability level. But 75% probability level is considered important for crop planning. 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. Highest rainfall of 289.1 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 837.9 mm is received in rest six month period from May to October.

Table 3: Monthly rainfall probability

Month	Probability			
	90%	75%	50%	Mean(mm)
January	0.2	0.8	2.4	2.9
February	0.2	1.4	6.0	11.7
March	0.2	1.5	8.0	19.2
April	0.3	2.0	8.3	16.3
May	11.4	30.7	73.1	103.7
June	71.8	108.4	162.5	178.6
July	142.4	191.5	258.5	273.0
August	210.5	289.1	397.7	423.4
September	111.2	161.7	234.4	254.3
October	21.9	56.5	130.8	182.8
November	1.9	9.5	36.4	70.4
December	0.0	0.6	6.7	28.4

Discussion

At 75% probability level during monsoon season Puri district received about 894.7 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. Senapati *et al.* (2009) [8], 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 uplands. 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 Puri is low. During the winter season (40th week onwards), negligible rainfall is recorded at 75% probability level. Therefore the surface soil would become dry with rare chances of getting adequate soil-moisture in the seeding zone, if possible, water harvesting should be done to ensure a pre-sowing irrigation. 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 moisture more judiciously as reliability of getting adequate weekly rainfall is low. If irrigation facilities are available, then early sown varieties may be grown with the application of pre-sowing irrigation. Bhadoria *et al.* (2013) analysed the rainfall in the rainy season. There is an ample scope for rain water harvesting from July to September

which can be utilized as crop saving irrigation as well as pre-sowing irrigation for succeeding Rabi crops which are generally sown on residual soil moisture. During summer season Puri district is likely to get 44.1 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. During post-monsoon (October, November) season, Puri district likely to get 74.4 mm rainfall at 75% probability level. The pre-rabi crops like green gram, black gram, horse gram and sesame can be taken in upland and vegetables like cucurbits, lady's finger, cowpea, cole crops can be grow in medium land as second crop.

Probability analysis of weekly rainfall can be taken or may be considered as a base for comparing out of agricultural operations throughout the year. Puri district received 17.9 mm rainfall on 25th SMW. With this amount of rainfall the farmers can go for summer ploughing to control weeds, soil borne pathogens and hibernated larvae. However from 23rd week onwards farmers can go for summer ploughing as the districts may receive rainfall of 5.7 mm. Therefore summer ploughing can be continued from 23rd to 25th week. The monsoon may be onset during 26th or 27th week. Prior to monsoon onset sowing of direct seeded rice in medium and low land can be carried out within 24 to 25th week to have better germination after the first shower of monsoon. From 31st to 33rd week, district is going to receive more than 100 mm rainfall so that beushining of direct seeded rice can be carried out. After the onset of monsoon during 26-27 week nursery raising of rice can be started in dry bed nursery so that transplanting may be made in 31st- 33rd week. The Initial and conditional rainfall probability analysis at Damoh reinforced that Initial probabilities {P(W)} of getting 10 mm rainfall per week was 76% during 25th (18-24 June) SMW. Thus, the seed bed preparation could be initiated during this week. Initial as well as conditional probability of wet week followed by wet week {P(W/W)} of getting 20 mm rainfall was more than 80% during 27th SMW (2-7 July) in Sagar district. Therefore, this week is most suitable for sowing operation in this district (Rai *et al.*, 2014) [6].

As the monsoon may be with drown by 39th week or may be extended up to 41st week (1st week of October), the medium duration rice in medium land and non paddy crops in upland can be harvested by 41st week without any moisture stress. At the reproductive stage, dependable rainfall (75%) was much higher than water requirements. Good drainage should be provided to reduce water stagnation. Similar results were found by Doorenbos *et al.* (1979) After harvest of medium duration rice in medium land non paddy short duration crops like pulses such as green gram, black gram, lathyrus, oilseeds like sesame can be grown for effective utilisation of soil moisture recharge by predicted post monsoon rainfall. Wheat, potato, mustard, lentil, chickpea, onion, cabbage, cauliflower etc. Jute, ladies finger can also be taken after harvesting of the transplanted rice at the beginning of October. The cropping patterns are based on rice. farmers can grow those crops provided the stored moisture after rice is utilized through immediate land preparation (by the middle of October).

As there is very little chances of rainfall occurrence after 47th week, no crop is advised to take up after 48th week in upland and medium land unless there is provision of irrigation facilities. There was continuous dry spell at the end of October which could be utilized for harvesting of rainy season crops and field preparations for winter season. High value

winter crops could be grown only with supplemental irrigation during winter season, starting from November

Conclusion

Puri received about 894.7 mm rainfall at 75% probability level during monsoon season. It is distributed, with the period from 25th to 40th weeks giving rise to or length of growing season 120 days or 17 weeks. Therefore the non paddy crops like groundnut, sunflower, short duration arhar of 120 days can be taken is upland during kharif season while during the winter season (40th week onwards), negligible rainfall is recorded at 75% probability level. Therefore the surface soil would become dry with rare chances of getting adequate soil-moisture in the seeding zone. The crops should be able to use residual soil profile moisture more judiciously as reliability of getting adequate weekly rainfall is low. If irrigation facilities are available, then early sown varieties may be grown with the application of pre- sowing irrigation.

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