Original Research Article

Analysis of Rainfall Probabilities and Crop Planning for different districts of Chhattisgarh

ABASTRACT

Rainfall data of 17 districts in ~~C.G.~~Chhattisgarh state has been used ~~in this research~~ to ~~find out~~determine the quantity of rainfall at different probability levels through incomplete gamma distribution. Bastar has the highest total annual rainfall, with 1090.0 mm, 1247.5 mm, and 1440.0 mm, respectively, at 90 percent, 75 percent, and 50 percent likelihood levels. Sukma district has the highest total annual rainfall with 1696.6 mm and 1955.3 mm at the 25% and 10% probability levels, respectively. At 90 percent and 75 percent probability levels, Bilaspur district has the lowest total annual rainfall of 300.8 mm and 542.8 mm, respectively. Kabirdham district has the lowest total annual rainfall at 50%, 25%, and 10% likelihood levels, with 983.1 mm, 1126.4 mm, and 1267.0 mm, respectively. Sukma district has the most rainfall (1466.6 mm) while Kabirdham district has the least (996.1 mm). Crop planning strategies have been designed in several districts of C.G. based on probability analysis. Potential crops are found by examining the appropriate agro-ecosystem, and suitable recommended types for production in various places are indicated. Only the inclusion of maize and sugarcane crops in cropping systems is being criticised.~~Among all the districts Bastar has highest total annual rainfall at 90%, 75% and 50% probability levels amounting 1090.0 mm, 1247.5 mm and 1440.0 mm respectively. Sukma district has highest total annual rainfall at 25% and 10% probability levels amounting 1696.6 mm and 1955.3 mm respectively. Bilaspur district has lowest total annual rainfall at different probability levels of 90% and 75% i.e. 300.8 mm and 542.8 mm respectively. At 50%, 25% and 10% probability levels Kabirdham district has lowest total annual rainfall i.e. 983.1 mm, 1126.4 mm and 1267.0 mm respectively. Mean rainfall is highest in Sukma district 1466.6 mm and lowest in Kabirdham district 996.1 mm. Based on the probability analysis, crop planning strategies have been designed in different districts of C.G. In this, potential crops are identified looking into suitable agro- ecosystem and suitable recommended varieties are suggested for

~~cultivation in different regions. Only stress is put up for including maize and sugarcane crop in cropping systems.~~

KEY WORDS: - Probability, rainfall, incomplete gamma distribution, crop planning

1. INTRODUCTION

Rain-fed, disaster-prone, and climate-vulnerable agriculture accounts for over 60% of Indian agriculture. Climate variability, especially rainfall, is the most important factor influencing agricultural productivity and sustainability in the tropics. Droughts and heavy rainfall events are becoming increasingly common around the world, posing a danger to ecosystems and, in particular, agricultural production and productivity. Rainwater management and usage is a primary focus of current research for the long-term viability of drenched agriculture. A good study of rainfall distribution can help determine the ideal periods for various agricultural operations and crop planning, which can help solve the problem. Crop type, climate, soil quality, geography, and socioeconomic status are all elements that influence crop planning in a specific area. However, in rainfed locations, it is primarily determined by the amount and distribution of rainfall over time and place. The rainfall pattern influences the cultivation of crops, their types, and the adoption of cultural activities. Water harvesting structures for agricultural activities, field preparation, seeding, irrigation, fertiliser application, and crop planning in general require information about a region's yearly and seasonal rainfall. As a result, the annual and seasonal rainfall trends, as well as weekly rainfall probability, are helpful for crop planning in a specific place.~~Around 60% of Indian agriculture is rain-dependent, disaster-prone and climate-vulnerable. In the tropics, climate variability, particularly rainfall, is the most important factor impacting agricultural productivity and sustainability. Drought and heavy precipitation events are becoming more common around the world, posing a threat to ecosystems, particularly agricultural production and productivity. Rainwater management and its utilization is a major focus of current research for rained agriculture's long-term viability. To address the problem, a thorough understanding of rainfall distribution can aid in determining the best times for various agricultural operations and crop planning. Crop planning in a given area is influenced by a number of factors, including crop type, climate, soil qualities, geography and socio economic status. However in rainfed areas, it is mainly dependent upon the magnitude and distribution of rainfall both in space and time. The cultivation of crops, their types and the adoption of cultural activities are all determined by the rainfall pattern. Information about a region's yearly and seasonal rainfall is useful for designing~~

Comment [A1]:

~~water harvesting structures for agricultural activities, field preparation, seeding, irrigation, fertilizer application and crop planning in general. As a result, the annual and seasonal trend of rainfall and weekly rainfall probabilities are useful for crop planning in a given location.~~

The farming community is well aware of the weather and its fluctuation, both of which have a significant impact on crop productivity. Rainfall is an important climatic indicator in crop planning, particularly in rainfed agriculture regions (Biswal et al., 2019). Bhelawe et al., 2015 used incomplete gamma probability to assess rainfall data from the last 43 years (1971-2013). Tabish et al. (2015) used Wei-formula bull's to calculate the observed values. The maximum rainfall values were calculated using the Gumbel, Log Pearson Type III Log Normal, and Gamma projected models. Rainfall probability analysis allows for a better prediction of the minimum assured rainfall, which aids crop planning in rainfed areas. Based on 12-year (2001-2012) data from Bilaspur, Chhattisgarh, an attempt was made to examine rainfall distribution patterns, including weekly, seasonal, and annual rainfall (Sinha et al., 2017).~~The weather and its variability are well known to the farming community and have great impact on crop production and have great impact on crop production. Rainfall is one of the most important climatic parameter in crop planning especially in region of rainfed agriculture (Biswal *et al.*, 2019). Bhelawe *et al.*, 2015 analyzed the rainfall data of recent forty three years (1971-2013) through incomplete gamma probability. Tabish *et al.* 2015 computed the observed values were by wei bull's formula. The maximum rainfall values were estimated by proposed predicted models viz. Gumbel, Log Pearson Type III Log Normal and Gamma. Probability analysis of rainfall offers a better scope for predicting the minimum assured rainfall to help in crop planning in rainfed regions.~~ An attempt has been made to evaluate rainfall distribution patterns i.e. weekly, seasonal and annual rainfall, based on 12 years (2001-2012) data of Bilaspur, Chhattisgarh (Sinha *et al.*, 2017).

Comment [A2]: Please specify the objectives of study and also the hypothesis of this subject in Chhattisgarh state

2. MATERIALS AND METHOD

The data required for the rainfall analysis was collected form Department of Agrometeorology IGKV Raipur.

Comment [A3]: Specify the period

Table 1.1 Geographical location of selected 17 districts and long term data of rainfall availability.

S.NO.	Districts	Stations	Latitude	Longitude	Database Period
1	Balrampur	Wadrafnagar	$23^0$11'N	$83^0$19'E	2003 - 2019
2	Bastar	Jagdalpur	$19^0$05'N	$82^0$02'E	1980 – 2019
3	Bemetara	Bemetara	$21^0$70'N	81^0 53'E	1960 – 2019
4	Bilaspur	Bilaspur,Kota, Pendra, Pendraroad	$22^0$05'N	$82^0$08'E	1972 – 2019
5	Dantewada	Dantewada	$18^0$53'N	$81^0$21'E	1973 – 2019
6	Gariyaband	Rajim,Deobhog, Gariyaband	$20^0$63'N	$82^0$06'E	1972 – 2019
7	Jashpur	Bagicha, Jaspurnagar, Kunkari	$22^0$83'N	$84^0$14'E	1972 -2019
8	Kabirdham	Kabirdham, Bodla	$22^0$01'N	$81^0$15'E	1963 – 2019
9	Kanker	Kanker	$20^0$16'N	81^0 30'E	1981 – 2019
10	Kondagaon	Kondagaon	$23^0$21'N	$82^0$21'E	1999 – 2019
11	Koriya	Manendragarh	$23^0$15'N	$82^0$34'E	1974 – 2019
12	Korba	Kanki, Korba	$22^0$00'N	$82^0$42'E	1960 – 2019
13	Mungeli	Mungeli	$22^0$05'N	$81^0$68'E	1972 – 2019
14	Rajnandgaon	Ambagarhchowki, Gandai, Khairagarh, Mohala, Rajnandgaon	$21^0$05'N	81^0 02'E	1962 – 2019
15	Sukma	Sukma	$18^0$40'N	$81^0$67'E	1972 – 2019
16	Surajpur	Pratappur	$23^0$22'N	$82^0$85'E	1973 - 2019
17	Surguja	Ambikapur	$23^0$07 'N	$83^0$12'E	1973 – 2019

2.1 Weather cock

Weather cock with version 15 ~~is software developed by (~~Rao *et al*.~~.~~ ~~(~~2011) under All India Co-ordinated Research Project CRIDA, Hyderabad was used ~~. It contains various modules such as data management, data quality, daily data conversions, rainfall analysis, temperature analysis, length of growing period and water balance. Application under~~for rainfall analysis ~~have been found viz.,~~such as agricultural drought, meteorological drought, high rainfall events, incomplete gamma probability, initial and conditional probabilities, probability of dry and wet weeks~~,~~ ~~,~~and rainy days ~~etc~~.

2.2 Rainfall probability

The probability of rainfall enables us to determine the expected rainfall at various chances. Rainfall data of Balrampur, Bastar, Bemetara, Bilaspur, Dantewada, Gariyaband, Jashpur, Kabirdham, Kanker, Kondagaon, Korba, Koriya, Mungeli, Rajnadgaon, Sukma, Surajpur and Surguja districts of Chhattisgarh were used to find weekly rainfall probability. It is estimated for each district separately using WEATHER COCK software which is developed by CRIDA, Hyderabad for weather data analysis.

Comment [A4]: Keep it in past tense

1. Never rename the Weather Cock folder.

2. All data files 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 analyzing 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

Bastar

Year, Week, RF (MM)

2019, 1, 0

2019, 2, 0

Incorrect data file

Bastar

Year, week, RF (MM),,,,

2019, 1, 0,,,,

The outline deals with research method and procedures are as follow.

2.3 Analysis of weekly rainfall Probability

Weekly rainfall probability was calculated through the model named as "Incomplete Gamma Distribution". Districts wise weekly rainfall data were used to calculate ~~districts wise~~ weekly rainfall quantum at a level of 90%, 75%, 50%, 25% and 10% for a year. Amount of rainfall at five probability levels has been computed for each standard week ~~by fitting~~using Incomplete Gamma Distribution model.

3. RESULTS AND DISCUSSION

Among all the districts Bastar has highest total annual rainfall through incomplete gamma distribution at 90%, 75% and 50% probability levels amounting 1090.0 mm, 1247.5 mm and 1440.0 mm respectively(Table 1.2). Sukma district has highest total annual rainfall at 25% and 10% probability levels amounting 1696.6 mm and 1955.3 mm respectively. Bilaspur district has lowest total annual rainfall at different probability levels 90% and 75% i.e. 300.8 mm and 542.8 mm respectively. At 50%, 25% and 10% probability levels Kabirdham district has lowest total annual rainfall i.e. 983.1 mm, 1126.4 mm and 1267.0 mm respectively. Mean rainfall is highest in Sukma district 1466.6 mm and lowest in Kabirdham district 996.1mm.

Comment [A5]: reframe

Table 1.2 Annual rainfall quantum through incomplete gamma distribution at different probability levels for different districts of Chhattisgarh

District	90%	75%	50%	25%	10%	Mean (mm)
Balrampur	780.0	920.3	1095.3	1291.1	1486	1117.2
Bastar	1090.0	1247.5	1440.0	1651.0	1857.7	1459.5
Bemetara	812.0	945.8	1111.1	1294.5	1475.9	1130.1
Bilaspur	300.8	542.8	990.0	1673.7	2520.8	1189.6
Dantewada	990.1	1154.7	1358.3	1584.6	1808.3	1382.2
Gariyaband	901.0	1021.8	1168.3	1328.2	1484.0	1182.0
Jashpur	1052.4	1181.4	1336.8	1505.3	1668.5	1350.2
Kabirdham	745.6	852.6	983.1	1126.4	1267.0	996.1
Kanker	835.5	974.9	1147.5	1339.4	1529.1	1167.7
Kondagaon	940.7	1064.4	1214.2	1377.5	1536.0	1228.0
Korba	868.7	1003.9	1170.1	1353.7	1534.4	1188.2
Koriya	848.0	1005.5	1202.4	1423.6	1644.0	1228.0
Mungeli	793.8	894.4	1015.8	1147.8	1275.9	1026.4
Rajnandgaon	856.0	965.4	1097.6	1241.4	1381.0	1109.3
Surguja	844.8	1037.4	1284.1	1567.4	1854.9	1323.1
Sukma	1019.4	1205.1	1436.8	1696.6	1955.3	1466.6
Surajpur	966.6	1101.6	1266.0	1446.0	1621.8	1282.2

On the basis of study district wise crop planning of three agro-climatic zones are given below. Cropping sequence is proposed in such a way so as to include maize and sugarcane crops in the cropping sequences.

1. Chhattisgarh plain:-

Maize – Mustard/ safflower, Maize – chickpea, Maize- vegetable, Sugarcane + Urd/Moong/leafy vegetables

2. Bastar plateau:-
   Maize – Green gram/ Black Gram, Maize – Vegetable, Millets / Niger – Leafy vegetables, Sugarcane + Urd/Moong/leafy vegetables, Rice- maize
3. Northern hills :- Maize - Mustard, Rice – Wheat / Mustard, Sugarcane, Pigeon pea – Vegetable

Table 1.3 Varieties for rainfed and irrigated condition

Rainfed condition	**Irrigated condition**
Varieties:- Rice: – Indira Barani Dhan-1, Danteswari, Anjali, Samleswari Lathyrus:- Ratan, Pratik, Mahatiwda, Black gram:- Barkha Wheat:- C-306, Lok-1 Soybean:- J.S.-95-60 Maize:- Narmada moti, Vivek sanker makka -1, Vivek sanker-9 Mustard:- Indira Toriya -1 Pigeonpea:- Jagriti, Chhattisgarh Arhar-1, Green gram:- Pusa Vishal Field pea :- Vikash, Indira Mater – 1 Safflower :- Nari – 6, Nari H- 15	Varieties:- Rice:- IGKV R-1, Mahamaya, Badshabhog, Gram:- Pusa subhra, Vaybhav, Indira chana -1 Wheat:-Sujata, G.W.- 322 Maize:-Bio-9544, 900M Gold Soybean:- C.G. Soya-1,J.S.-97-52 Mustard:-Pusa jai kishan, vardan Pigeonpea:- Rajiv Lochan, Asha Sugarcane:- Co-80036, Co- 86032,Co-8014

4. CONCLUSION

Among all the 17 districts Bastar has highest total annual rainfall at 90%, 75% and 50% probability levels amounting 1090.0 mm, 1247.5 mm and 1440.0 mm respectively. Sukma district has highest total annual rainfall at 25% and 10% probability levels amounting 1696.6 mm and 1955.3 mm respectively. Bilaspur district has lowest total annual rainfall at different probability levels of 90% and 75% i.e. 300.8 mm and 542.8 mm respectively. At 50%, 25% and 10% probability levels Kabirdham district has lowest total annual rainfall i.e. 983.1 mm, 1126.4 mm and 1267.0 mm respectively. Mean rainfall is highest in Sukma district 1466.6 mm and lowest in Kabirdham district 996.1 mm.

Comment [A6]: rewrite.specific findings highlighted to conclude your study must be given . It is repeatedly mentioned in abstract, discussion and conclusion

REFERENCES

1. Bhargava, A. K. Singh, P. K., Mitra, V., Prasad, A. and Jayapalan, M. (2010). Rainfall variability and probability pattern for crop planning of Roorkee region (Uttarakhand) of India. Mausam, 61(4): 509-516.
2. Bhavyashree, S. and Bhattacharyya, B. (2018). Fitting Probability Distributions for Rainfall Analysis of Karnataka, India. Int. J. Curr. Microbiol. App. Sci, *7*(3): 1498-1506.
3. Bhelawe, S., Manikandan, N., Khavse, R., Chaudhary, J. L. and Patel, S. R. (2015). Analysis of rainfall probabilities for strategic crop planning in Raipur district of Chhattisgarh state. Current World Environment, 10(1): 253-257.
4. Biswal, B. R., Baliarsingh, A., Pradhan, J., Das, M. P., Mohapatra, A. K. B. and Rath, B. S. (2019). Rainfall probability analysis for contingent crop planning in Ganjam (Odisha):422-425.
5. Dabral, P. P., Dada, M. and Odi, H. (2019). Probability analysis of rainfall at Kohima (Nagaland) for crop planning. Journal of Soil and Water Conservation, 18(4): 364-371.
6. Sahoo, D. C., Madhu, M. and Mohanraj, R. (2008). Probability analysis of rainfall for Udhagamandalam. Journal of Agrometeorology, 10(1): 65-69.
7. Sattar, A. (2010). Rainfall probability analysis for different agroclimatic zone of Bihar. J. Agrometeorol, 12(2): 261-262.
8. Sinha, B. L., Sinha, J., Sahu, R. K., Sinha, B., Sahu, B. and Patel, M. (2017). Rainfall probability analysis for crop planning in Bilaspur region of Chhattisgarh plain. Satellite remote sensing of salt-affected soils: Potential and limitations 97, 16(2): 151-156.
9. Subudhi, C. R., Suryavanshi, S., and Jena, N. (2019). Rainfall probability analysis for crop planning in Bargarh district of Odisha, India. Biomettrics and Biostatistics International Jounal, 8(5): 178-182.
10. Tabish, M. O. H. D. Ahsan, M. J., and Mishra, A. (2015). Probability Analysis for Prediction of Annual Maximum Rainfall of One to Seven Consecutive Days for Ambedkar Nagar Uttar Pradesh. IJASR, 6, 47-54.

Comment [A8]: Arrange as per journal format