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RAINFALL PROBABILITY ANALYSIS FOR CROP PLANNING IN ANUGUL BLOCK OF ANUGUL DISTRICT OF HIRAKUD COMMAND AREA OF ODISHA, INDIA

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ABSTRACT

This study was under taken in the U.G. thesis work in the Dept. Of SWCE, CAET, OUAT, Bhubaneswar during the year 2018-19.Anugul district has latitude of 20°50'40''N and a longitude of 85° 09'04''E. The district has been divided into four sub-divisions and eight blocks. Out of which the rainfall data of Anugul block was taken for thesis purpose. The average rainfall at Anugul block is around 1264.4 mm, Most of the rainfall occurred during kharif.So most of the crops get low yield due to improper crop planning. Thus, this study is proposed to be undertaken with the objective, probability analysis of annual, seasonal and monthly rainfall data of Anugul block. So rainfall data were collected from OUAT, Agril Meteorology Dept. from 2001 to 2017(17 years) monthly, seasonal and annual rainfall were analysed. Probability analysis has been made and equations were fitted to different distributions and best fitted equations were tested. Monthly, Annual and seasonal probability analysis of rainfall data shows the probability rainfall distribution of Anugul block in different months, years and seasons by using flood software. It is observed that rainfall during June to Sep is slightly less than 1000 mm and cropping pattern like paddy(110 days) may be followed by mustard is suitable to this region. Also if the kharif rain can be harvested and it can be reused for another rabi crop by using sprinkler or drip irrigation, which will give benefit to the farmers. Annual rainfall of Angul is 1264.4 mm at 50% probability level.

KEYWORDS: *Command Area, Crop Planning, Hirakud, Probability Analysis, Rainfall*

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INTRODUCTION

Anugul district has latitude of 20°50'40"N and a longitude of 85° 09'04"E. The district has been divided into four sub-divisions and eight blocks. Out of which the rainfall data of Anugul block was taken for thesis purpose. The average rainfall at Anugul district is around 1421mm, though it receives high amount rainfall but most of the rainfall occurred during *kharif*. Thus, this study is proposed to be undertaken with the following objective: Probability analysis of annual, seasonal and monthly rainfall data of Anugul block of Anugul district.

Thom (1966) employed mixed gamma probability distribution for describing skewed rainfall data and employed approximate solution to non-linear equations obtained by differentiating log likelihood function with respect to the parameters of the distribution. Subsequently, this methodology along with variance ratio test as a goodness- of-fit has been widely employed *Kar et. al* (2004), *Jat et. al* (2006), *Senapati et. al* (2009) applied incomplete gamma probability distribution for rainfall analysis. In addition to gamma probability distribution, other two-parameter probability distributions (normal, log-normal, Weibull, smallest and largest extreme value), and three-parameter probability distributions (log-normal, gamma, log-logistic and Weibull) have been widely used for studying flood frequency, drought analysis and rainfall probability analysis (*Senapati et. al*.2009).

Gumbel (1954) *Chow* (1964), have applied gamma distribution with two and three parameter, Pearson type-III, extreme value, binomial and Poisson distribution to hydrological data.

MATERIALS AND METHODS

The data were collected from District Collector's Office, Anugul for this study. Rainfall data for17 years from 2001 to 2017 are collected for the presented study to make rainfall forecasting through different methods

Probability Distribution Functions

For seasonal rainfall analysis of Anugul block, three seasons- *kharif* (June-September), *rabi* (October to January) and summer (February to May) are considered.

The data is fed into the Excel spreadsheet, where it is arranged in a chronological order and the Weibull plotting position formula is then applied. The Weibull plotting position formula is given by

$$.p = \frac{m}{N+1}$$

where *m*=rank number

N=number of years

The recurrence interval is given by

$$.T = \frac{1}{p} = \frac{N+1}{m}$$

The values are then subjected to various probability distribution functions namely- normal, log-normal (2-parameter), log-normal (3-parameter), gamma, generalized extreme value, Weibull, generalized Pareto distribution, Pearson, log-Pearson type-III and Gumbel distribution. Some of the probability distribution functions are described as follows:

Normal Distribution

The probability density is

$$.p(x) = (1/\sigma\sqrt{2\pi})\ e^{-(x-\mu)^2/2\sigma^2}$$

where x is the variate, μ is the mean value of variate and σ is the standard deviation. In this distribution, the mean, mode and median are the same. The cumulative probability of a value being equal to or less than x is

$$.p(x \leq) = 1/\sigma\sqrt{2\pi} \int_{-\infty}^{x} e^{-(x-\mu)^2/2\sigma^2} dx$$

This represents the area under the curve between the variates of $-\infty$ and x.

Log-Normal (2-Parameter) Distribution

The probability density is

$$.p(x) = (1/\sigma_y\, e^y\sqrt{2\pi})e^{-(y-\mu_y)^2/2\sigma_y}$$

where $y = ln\ x$, where x is the variate, μ_y is the mean of y and σ_y is the standard deviation of y.

Log-normal (3-parameter) distribution

A random variable X is said to have three-parameter log-normal probability distribution if its probability density function (pdf) is given by:

$$.f(x) = \begin{Bmatrix} \frac{1}{(x-\lambda)\sigma\sqrt{2\pi}} exp\left\{-\frac{1}{2}\left(\frac{\log(x-\lambda)-\mu}{\sigma}\right)^2\right\}, \lambda < x < \infty, \mu > 0, \sigma > 0 \\ 0, \text{otherwise} \end{Bmatrix}$$

where μ, σ and λ are known as location, scale and threshold parameters, respectively.

Pearson Distribution

The general and basic equation to define the probability density of a Pearson distribution

$$.p(x) = e\int_{-\infty}^{x} \frac{a+x}{b_0+b_1x+b_2x^2}dx$$

where a, b_0, b_1 and b_2 are constants.

The criteria for determining types of distribution are β_1, β_2 and k where

$$.\beta_1 = \frac{\mu_3^2}{\mu_2^3}$$

$$.\beta_2 = \frac{\mu_4}{\mu_2^2}$$

$$.k = \frac{\beta_1(\beta_2+3)^2}{4(4\beta_2-3\beta_1)(2\beta_2-3\beta_1-6)}$$

Where μ_2, μ_3 and μ_4 are second, third and fourth moments about the mean.

Log-Pearson Type III Distribution

In this the variate is first transformed into logarithmic form (base 10) and the transformed data is then analyzed. If X is the variate of a random hydrologic series, then the series of Z variates where

$$.z = logx$$

are first obtained. For this z series, for any recurrence interval T and the coefficient of skew C_s,

$.\sigma_z$ =standard deviation of the Z variate sample

$$. = \sqrt{\sum(z-\bar{z})^2/(N-1)}$$

.And C_s =coefficient of skew of variate Z

. $=\frac{N\sum(z-\bar{z})^3}{(N-1)(N-2){\sigma_z}^3}$

.$\bar{z}$= mean of z values

.N= sample size = number of years of record

Generalized Pareto Distribution

The family of generalized Pareto distributions (GPD) has three parameters μ, σ and ξ.

The cumulative distribution function is

$$.F_{(\varepsilon,\mu,\sigma)}(x) = \begin{Bmatrix} 1-\left(1+\frac{\xi(x-\mu)}{\sigma}\right)^{\frac{-1}{\xi}} for\ \xi \neq 0 \\ 1-\exp\left(-\frac{x-\mu}{\sigma}\right)\ for\ \xi = 0 \end{Bmatrix}$$

for $x \geq \mu$ when $\xi \geq 0$ and $x \leq \mu - \frac{\sigma}{\xi}$ when $\xi < 0$,where $\mu \in \mathbb{R}$ is the location parameter, $\sigma > 0$ the scale parameter and $\xi \in \mathbb{R}$ the shape parameter.

The probability density function is

$$.f_{(\xi,\mu,\sigma)}(x) = \frac{1}{\sigma}(1+\frac{\xi(x-\mu)}{\sigma})^{\left(-\frac{1}{\xi}-1\right)}$$

Or

$$.f_{(\xi,\mu,\sigma)}(x) = \frac{\sigma^{\frac{1}{\xi}}}{(\sigma+\xi(x-\mu))^{\left(\frac{1}{\xi}+1\right)}}$$

again, for$x \geq \mu$, and $x \leq \mu - \frac{\sigma}{\xi}$ when $\xi < 0$

RESULT AND DISCUSSIONS

The various parameters like mean, standard deviation, RMSE value, were obtained and noted for different distributions. For generalized extreme value and generalized Pareto distribution the other parameters like shape parameterξ, scale parameter σ and location parameter μ are also noted for further calculation. Similar procedure is followed for the seasonal, annual and pentad analysis. The rainfall at 90%, 75%, 50%, 25% and 10% probability levels are determined. The distribution “best” fitted to the data is noted down in a tabulated form in Table 1.

Table 1: Rainfall Analysis of Anugul Block at Different Probability Levels for Different Months and Season

Months, Seasons and Annual	Best Fit Distribution	RMSE Value	Rainfall At Probability Levels				
			90%	75%	50%	25%	10%
January	Gamma	0.06788	-	-	.42	20.7	68.5
February	Log normal	0.06885	-	-	2.1	9.7	25.4
March	Gamma	0.03867	-	4	15.4	36.1	66.9
April	Pareto	0.04128	-	5.2	24.2	43.5	55.2
May	Weibull	0.04255	26.5	42.4	63.7	87.9	111.2
June	Log-normal(3-p)	0.04961	81.4	116.1	159.5	208.5	258
July	Gumbell maximum	0.03945	132	196.5	284.7	396.5	524.3
August	Log-Pearson	0.0417	119.6	191.3	279.6	360.9	416.6
September	Log-normal	0.03854	96.3	133.3	191.1	274.1	379.4
October	Pareto	0.07058	6.8	31.1	82	159.5	246
November	Gamma	0.06489	-	-	.86	19.3	50
December	EV type-iii	-	-	-	-	-	-
Kharif, (June-Sept)	Log-normal(3-p)	0.05945	741.7	845.5	963.3	1083.6	1194.3
Rabi (Oct-Jan)	Pareto	0.03543	9.4	42.5	107.6	196.1	279.7
Summer (Feb-May)	Pareto	0.03657	43.2	69.7	118.2	175.6	219.8
Annual	EV type-iii	0.03671	926.6	1120.3	1264.4	1382	1470.5

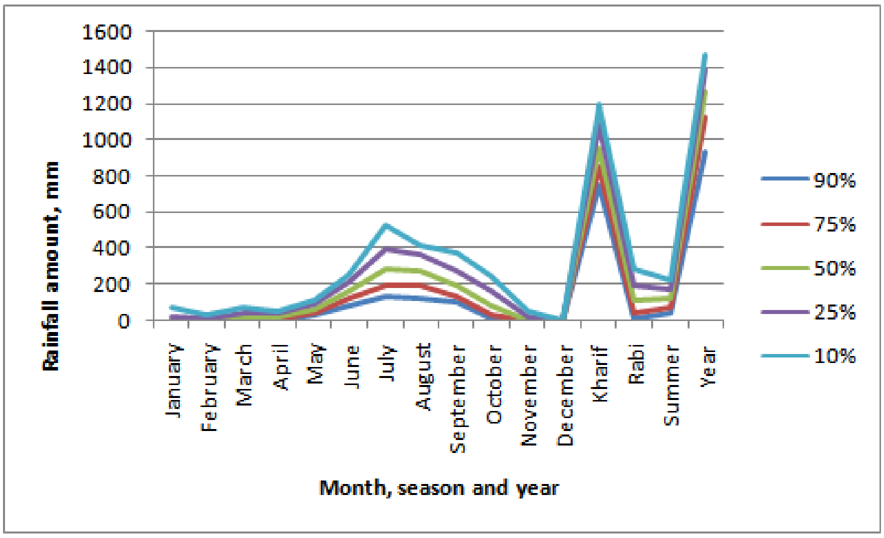

Figure 1: Rainfall at Different Probabilities of Monthly, Seasonal and Annual at Anugul Block

In the present study, the parameters of distribution for the different distributions have been estimated by FLOOD-flood frequency analysis software. The rainfall data is the input to the software programme. The best fitted distribution of different month and season and annual were presented in Table 1. The annual rainfall in 50% probability was found to be 1264.4 mm for Anugul block of Odisha. During Kharif at 50 % probability level, the rainfall is 963.3 mm where as only 107.6mm and 118.2 mm was received during rabi and summer respectively, so water harvesting structures may be made to grow crops during rabi and summer to utise the water from the water harvesting structures to increase the cropping intensity of the area. It is also observed that at 75 % probability level the June,July, Aug and Sept received more than 100 mm, so farmers of these area can grow crops in upland areas suitably paddy can be grown followed by any rabi crop in *rabi* season like mustard or kulthi in upland areas. I n Fig 1 the plot between different months and amount of rainfall in different probabilities were shown, It is observed that July month gets highest amount of rainfall compared to other months.

CONCLUSIONS

Forecasting of rainfall is essential for proper planning of crop production. About 70% of cultivable land of Odisha depends on rainfall for crop production. Prediction of rainfall in advance helps to accomplish the agricultural operations in time. It can be concluded that, excess runoff should be harvested for irrigating post-monsoon crops. It becomes highly necessary to provide the farmers with high-yielding variety of crops and such varieties which require less water and are early-maturing in Anugul block of Hirakud command area of Odisha. It is also observed that at 75 % probability level the June,July, Aug and Sept received more than 100 mm, so farmers of these area can grow crops in upland areas suitably paddy can be grown followed by any rabi crop in *rabi* season like mustard or kulthi in upland areas. Annual rainfall of Angul is 1264.4 mm at 50% probability level. It is observed that July month gets highest amount of rainfall compared to other months.

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