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RAINFALL PROBABILITY ANALYSIS FOR CROP PLANNING IN CUTTACK SADAR BLOCK OF CUTTACK DISTRICT OF ODISHA,INDIA

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ABSTRACT

This study was under taken in the U.G. work in the Dept. Of SWCE, CAET, OUAT, Bhubaneswar during the year 2020**.** Cuttack Sadar has latitude of 20° 28' 32'' N and longitude of 85° 51' 5328'' E. The average rainfall at Kalahandi district is around 1440 mm, though it receives high amount rainfall but 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 following objective: Probability analysis of annual, seasonal and monthly rainfall data of Cuttack block of Cuttack district. So, rainfall data were collected from OUAT, Agril Meteorology Dept. from 2001 to 2017(17 years) monthly, seasonal and annual rainfall were analyzed. Probability analysis have 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 Cuttack Sadar block of Cuttack district in different months, years and seasons. It is observed that rainfall during June to Sep is more than 100 mm and cropping pattern like paddy (110 days) may be followed by black gram 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.

Key words- Rainfall ; probability analysis ; crop planning,

INTRODUCTION

Cuttack district has altitude of 28m above mean sea level. Cuttack district has latitude of 20° 28' 32'' N and longitude of 85° 51' 5328'' E. The average rainfall at Cuttack district is 1440 mm, 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 Cuttack Sadar block of Cuttack 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); Panigrahi and Panda (2001), & (Subudhi, C.R. et.al.2019)

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, Kalahandi district 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 Kalahandi district, 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 namelynormal, 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:

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

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

$$p(x) = e \int_{-\infty}^{x} \frac{a+x}{b_0 + b_1 x + b_2 x^2} dx$$

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

$z = log x$

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

σ_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

<u>Generalized Pareto Distribution:-</u>

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

The cumulative distribution function is

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

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 $\xi < 0$

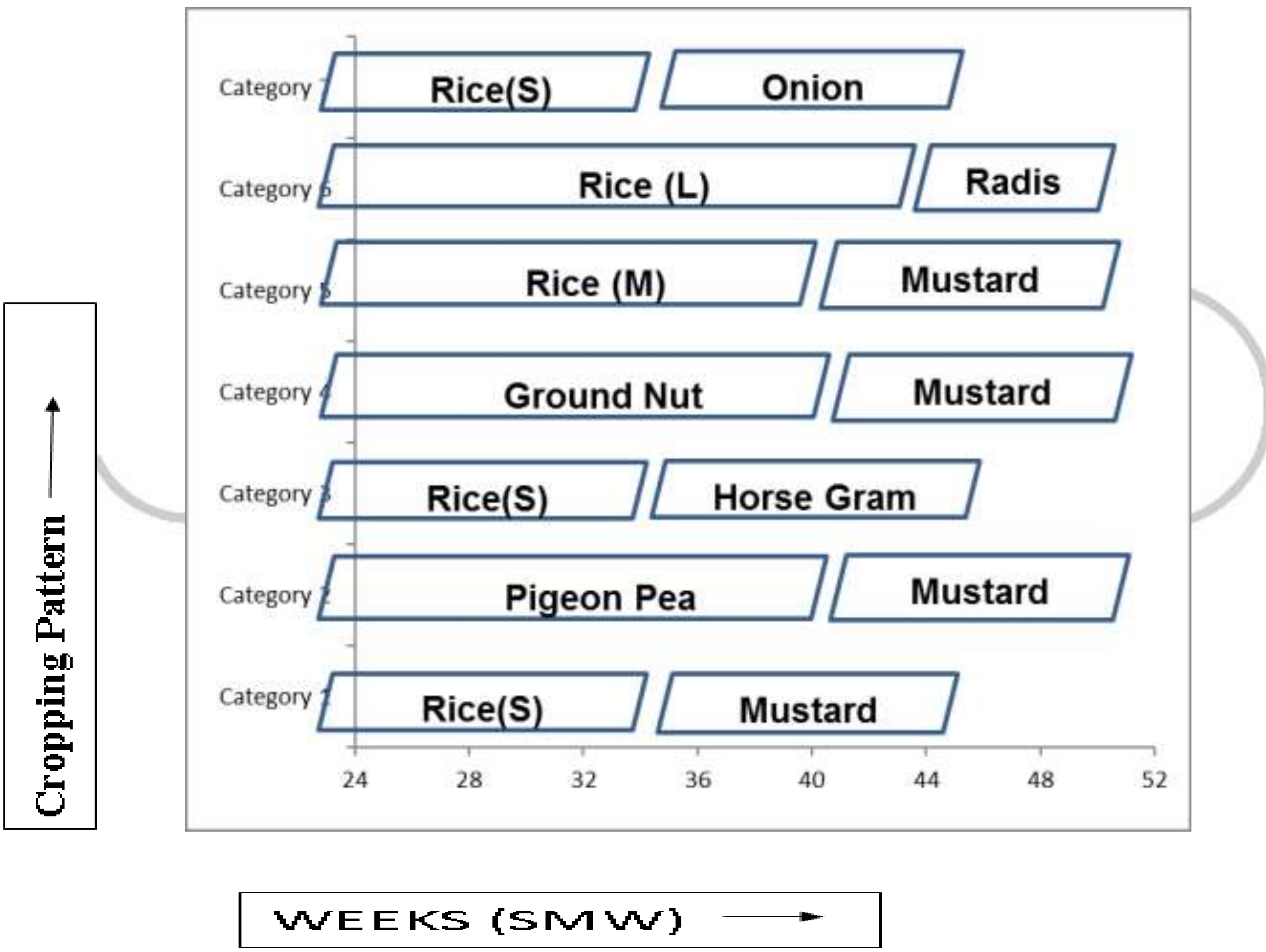
Result and discussion

The various parameters like mean, standard deviation, RMSE value were obtained and noted for different distributions. 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 Cuttack Sadar Block at different probability levels for different months and seasons.

Months	Best-fit Distribution	RMSE Value	Rainfall at probability levels				
			90%	70%	50%	20%	10%
January	General Pareto	0.051	-	-	-	37.9	64.2
February	Generalised Extreme Value	0.054	-	-	-	37.8	58.9
March	Log Pearson	0.071	-	-	-	15.8	52.4
April	Gamma	0.083	-	-	-	26.0	65.9
May	General Pareto	0.066	-	-	-	26.0	56.6
June	General Pareto	0.045	46.7	92.6	148.0	268.9	337.4
July	Generalised Extreme Value	0.027	171.2	249.8	320.7	478.8	593.5
August	Gumbel maximum	0.051	152.1	247.9	329.5	497.0	607.9
September	Normal	0.062	117.7	261.3	360.7	520.4	603.9
October	Log Pearson	0.048	174.1	246.8	317.2	480.2	599.0
November	General Pareto	0.04144	-	-	-	31.7	52.0
December	General Pareto	0.08016	--	-	--	4.1	24.8
Annual	Gumbel maximum	0.05234	2953.1	3196.1	3402.9	3827.6	4108.8
Kharif (June-Sept)	Gamma	0.06218	673.2	924.4	1131.6	1525.5	1763.0
Rabi (Oct-Jan)	Lognormal	0.02856	36.3	74.9	123.6	276.4	421.1
Summer (Feb-May)	EV type III	0.04541	1.4	61.8	102.1	170.3	207.2

In the present study, the parameters of distribution for the different distributions have been estimated by FLOOD frequency analysis software. The rainfall data is the input to the software programme. The best fitted distribution of different month and seasons and annual were presented in Table 1.During *Kharif* at 50% probability level, the rainfall is 1131.6 mm where as only 123.6 mm and 102.1 mm was received during *rabi* and *summer* respectively.



- Fig 1 Different cropping patterns for Cuttack Sadar block of Cuttack district

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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. so water harvesting structures may be made to grow crops during *rabi* and *summer* to utilize 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. It is observed that September month gets highest amount of rainfall compared to other months. Fig 1 shows the different cropping pattern in Cuttack Sadar block of Cuttack district as per the rainfall available in different weeks.

Conclusion

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 inCuttack district of of Odisha. It is also observed that at 70 % 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. It is observed that September month gets highest amount of rainfall compared to other months. Different cropping pattern selected may be may be practiced in this district.

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