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# Crop Planning of the Warangal District of Telangana State using Probability Distribution of 40 Years Rainfall Data

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***Abstract:*** ***Rain is a major component of the water cycle that deposits most of the fresh water on the earth. The determination of the frequency of occurrence of extreme hydrological events is a prerequisite for planning and execution of many water resource projects. A comprehensive statistical analysis on annual, monthly and seasonal rainfall for Warangal District, Telangana was performed using rainfall data for 40 years (1962-2001). The current investigation was conducted with the ultimate aim of determining the type of Probability distribution that best fits the rainfall data of that particular area. The plotting position and probabilistic methods of probability distribution functions were used for analysis of rainfall data. Rainfall magnitude were evaluated for different return periods. As well as the rainfall pattern of that area has been studied with help of standard deviation and co-efficient of variation. The difference in results obtained from the methods of plotting position were found to be insignificant. Chi-square test was used to measure the Goodness of fit for the seasonal and monthly rainfall. Gumbel's (Extreme value type-I) method and Normal method was found to be the best method of distribution for the rainfall data of this region. A detailed study was conducted on the crop planning of this region. Rainfall amount is decreasing gradually due to urbanization, global climatic change and hence a decrease in crop productivity. Despite the growth in percentage of gross-irrigated area over Rain-fed farming, Farmers are still rainfall dependent. Crop planning is done with the average effective rainfall of Warangal. Economic analysis is carried out for the crops cultivated in this region and farmers get 23% increase in their yield according to the rates available in Warangal market.***

***Keywords : Crop Planning, Economic Analysis, Probability Analysis, Rainfall,***

## I. INTRODUCTION

Rainfall has a significant impact on ventures in agriculture and water resources[1]. Therefore, from the available historical data, it is possible to estimate the depth of rainfall and its return time. Comprehensive and accurate information on the hydrological data of the area under investigation is needed for water resources planning and management at local or regional level [2,3]. A number of experiments in agricultural planning are performed using the Rainfall method [4-7]. Author conducted a study of variance and probabilities of effective crop planning on a weekly, monthly, seasonal and annual basis. Lot of research has been carried out in the field of rainfall [8].

## II. STUDY AREA

The Warangal research is situated at 79.58 ° E at 18.0 ° N. There is a tropical climate in Warangal in Telangana. The annual average rainfall is approximately 977 mm. Warangal has a climate that is mostly hot and dry. Summer starts in March and peaks at 42 ° C on average in May. The moonsoon starts in June and lasts with about 550 mm of precipitation until September. The difference in Warangal's average monthly rainfall is shown in Fig. 1. From the video. 1 The lowest average monthly rainfall occurs in January and the highest monthly average rainfall occurs in July.

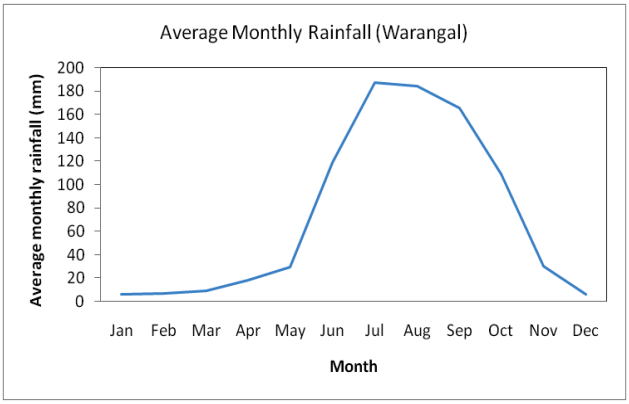


**Fig. 1 Average Monthly rainfall In Warangal**

## III. METHODOLOGY

### A. Parameters Used in Probability Distribution

Using probability distribution, various parameters are used in the Rainfall Analysis. Several criteria are as follows:

a) Arithmetic Mean
b) Standard deviation

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c) Co-efficient of Variation
d) Co-efficient of skew-ness
e) Maximum and Minimum rainfall

**B. Goodness of Fit**

Goodness of fit is a test used to find out the best fit probability distribution. The best fit distribution varies for different time period. The following are the various methods to determine the goodness of fit:

a) Kolmogrov-Smirnov test
b) Anderson-Darling test
c) Chi-Squared test

*Chi-squared test is used in the determination of best fit distribution for weekly, monthly and seasonal rainfall in this study.*

**Chi-Squared Test :** Chi-squared test can calculate the fitness between the observed events and the fitted distribution. The method is only used for continuously sampled data and is used to assess whether a sample originates from a particular distribution population. The general formula for the chi-square value is:

$$Xc^2 = \sum_{i=1}^{k} (O-E)^2 / E$$

Where, O = Observed frequency, E = Expected frequency, i = No. of observations and K= the total no. of data

**C. Procedure for Seasonal and Monthly Analysis**

The method for evaluating the seasonal, weekly and monthly rainfall is as follows:

1. The rainfall data are arranged with defined ranges at several intervals.
2. The Weibull, Standard and Gumbel methods were adopted for precipitation analysis.
3. Mean and standard deviation for clustered data are determined.
4. Probability density functions for all methods using generic formulas 5 have been determined. For all the processes, the chi-square values are determined.
6. The method that gives a minimum value of Chi-square is found to suit the distribution best.

**D. Procedure For Economic Analysis**

The economic theoretical method is as follows:

1. Total water needs and efficient precipitation are used for crop planning.
2. After the preparation of the harvest, farmers take the yield for different crops.
3. Tariffs for different crops are the result of the Warangal market.
4. Yield after crop preparation was taken from the farmers ' consultation and also from the Statistics and Program Implementation Ministry website.
5. The difference between the yield before and after crop planning is taken and multiplied by the price for different crops that gives us the farmer's benefit

Table 2 and Table 3, respectively, provide statistical criteria for seasonal and monthly rainfall analysis. Skew-ness is the distribution of mean data. In normal distribution, it is equal to zero. If the sample peak is to the right of a plotted graph, it is said to be skewed negatively, and if the sample peak is to the left of a plotted graph, it is said to be skewed positively. Table 1 shows the various formulas used for statistical analysis and rainfall probability analysis.

Mean relates to the average rainfall data of 40 years, where the rainfall difference about the mean is the standard deviation. Any time the standard deviation is greater than the mean, it reflects a greater variation in the pattern of rainfall.

**Table 1. Formula used for rainfall analysis**

**Table 2. Statistical Parameters for seasonal rainfall analysis**

| Description | Formula | Explanation |
|---|---|---|
| Arithmetic Mean ( $X_{avg}$ | $\sum X_i / n$ | X is the rainfall magnitude in mm, i=1, 2, .....n and 'n' is the length of the sample. |
| Standard deviation | $[\sum (X_i - X_{avg})^2 / (n-1)]^{1/2}$ | X is the rainfall magnitude in mm, i=1, 2, .....n and 'n' is the length of the sample. |
| Co-efficient of Variation $C_v$ | $100 \times (\sigma / X_{avg})$ | $X_{avg}$ is the Mean<br>$\sigma$ is the Standard deviation |
| Co-efficient of Skew-ness $C_s$ | $(1/\sigma^3) \times [(N/(N^2-3N+2)] \times \sum (X_i - X_{avg})^3$ | $\sigma$ is the Standard deviation<br>N is Total no. of years<br>$X_{avg}$ is the Mean<br>X is the rainfall magnitude in mm, i=1, 2, .....n |
| Probability density function (Plotting Position methods)<br>Weibull formula (P) | m/(n+1) | m is the rank and<br>n is total no. of years |
| Probability density function for Probabilistic methods<br>Gumbel Distribution (KC Patra, 2010)<br><br>Normal Distribution | $P(X) = \exp.((-(a+x)/c) - e^{-(-(a+x)/c)})$<br><br>$B = 0.5[1 + 0.196854\|Z\| + 0.115194\|Z\|^2 + 0.000344\|Z\|^3 + 0.015927\|Z\|^4]^{-4}$ | P(X) is the probability density function<br>$a = 0.450055\,\sigma - X_{avg}$ &<br>$c = 0.7797\,\sigma$<br><br>$Z = (X - X_{avg}) / \sigma$ F (Xi) = B for Z < 0 &<br>F (Xi) = 1-B for Z > 0<br><br>P(X) = F (Xi+1) – F(X) is the probability density function |
| Chi-square formula (KC Patra, 2010) | $Xc^2 = [(fs(Xi) - P(Xi))^2 / P(Xi)] \times \sum Ni$ | Xc is the Chi – squared value &fs(Xi) = Ni/N<br>P(X) is the probability density function |

| S NO | Statistical Parameters | South west Monsoon | North east Monsoon |
|---|---|---|---|
| 1 | Rainfall(mm) | 164.132 | 48.362 |
| 2 | Standard Deviation (mm) | 74.236 | 64.520 |
| 3 | Coefficient Of Variation | 0.452 | 1.334 |
| 4 | Coefficient Of Skewness | 0.836 | 1.878 |

**Table 3: Statistical Parameters for Monthly Rainfall Analysis**

| Months | Mean rainfall | Standard deviation | Coeff. of variation | Coeff. of skewness |
|---|---|---|---|---|
| Jan | 5.69 | 7.994 | 1.405 | 1.654 |
| Feb | 6.22 | 10.006 | 1.608 | 1.734 |
| Mar | 8.67 | 11.803 | 1.361 | 2.033 |
| Apr | 18.13 | 15.785 | 0.870 | 1.596 |
| May | 28.91 | 27.072 | 0.936 | 1.821 |
| Jun | 119.01 | 51.659 | 0.434 | 0.882 |
| Jul | 187.67 | 70.294 | 0.374 | 0.828 |
| Aug | 184.33 | 75.744 | 0.410 | 0.580 |
| Sep | 165.51 | 77.744 | 0469 | 1.032 |
| Oct | 109.31 | 75.814 | 0.693 | 0.850 |
| Nov | 29.97 | 29.252 | 0.976 | 0.854 |
| Dec | 5.80 | 9.125 | 1.572 | 1.834 |

## IV. RESULTS AND DISCUSSIONS

### A. Monthly rainfall analysis

The precipitation data is distributed in several intervals with a 25 mm range and the incidence rate is initially calculated to turn the usual data into a clustered data. In order to test the difference in rainfall, mean and standard deviation were found. The estimation using Weibul method for monthly analysis, Gumbel method for monthly analysis and Normal method for monthly analysis are shown in Table 4, Table 5 and Table 6 respectively. The related probabilities and chi-square values were estimated for monthly and seasonal precipitation analysis. The sum of all intervals chi-square values shows the method's chi-value. It is clear from all the tables that the probability decreases when the rainfall increases.

**Table 4 Calculations using Weibull method for Monthly analysis**

| RANK | RANGE | Ni | fs(Xi) | Fs(Xi) | P(Xi) | $Xc^2$ |
|---|---|---|---|---|---|---|
| 17 | <25 | 227 | 0.47292 | 0.47292 | 0.944 | 113.00 |
| 16 | 25-50 | 43 | 0.08958 | 0.56250 | 0.889 | 345.00 |
| 15 | 50-75 | 32 | 0.06667 | 0.62917 | 0.833 | 338.56 |
| 14 | 75-100 | 34 | 0.07083 | 0.70000 | 0.778 | 308.43 |
| 13 | 100-125 | 23 | 0.04792 | 0.74792 | 0.722 | 302.19 |
| 12 | 125-150 | 31 | 0.06458 | 0.81250 | 0.667 | 261.00 |
| 11 | 150-175 | 21 | 0.04375 | 0.85625 | 0.611 | 252.84 |
| 10 | 175-200 | 18 | 0.03750 | 0.89375 | 0.556 | 231.88 |
| 9 | 200-225 | 18 | 0.03750 | 0.93125 | 0.500 | 205.35 |
| 8 | 225-250 | 10 | 0.02083 | 0.95208 | 0.444 | 193.80 |
| 7 | 250-275 | 7 | 0.01458 | 0.96667 | 0.389 | 172.93 |
| 6 | 275-300 | 8 | 0.01667 | 0.98333 | 0.333 | 144.40 |
| 5 | 300-325 | 3 | 0.00625 | 0.98958 | 0.278 | 127.40 |
| 4 | 325-350 | 1 | 0.00208 | 0.99167 | 0.222 | 104.68 |
| 3 | 350-375 | 1 | 0.00208 | 0.99375 | 0.167 | 78.01 |
| 2 | 375-400 | 2 | 0.00417 | 0.99792 | 0.111 | 49.41 |
| 1 | >400 | 1 | 0.00208 | 1.00000 | 0.056 | 24.70 |

**Table 5: Calculations Using Gumbel method for monthly analysis**

| INTERVAL | RANGE | Ni | fs(Xi) | Fs(Xi) | X(mm) | P(X) | $Xc^2$ |
|---|---|---|---|---|---|---|---|
| 1 | <25 | 227 | 0.47292 | 0.47292 | 25 | 0.339 | 25.614 |
| 2 | 25-50 | 43 | 0.08958 | 0.56250 | 50 | 0.368 | 101.050 |
| 3 | 50-75 | 32 | 0.06667 | 0.62917 | 75 | 0.346 | 108.372 |
| 4 | 75-100 | 34 | 0.07083 | 0.70000 | 100 | 0.295 | 81.906 |
| 5 | 100-125 | 23 | 0.04792 | 0.74792 | 125 | 0.235 | 71.650 |
| 6 | 125-150 | 31 | 0.06458 | 0.81250 | 150 | 0.179 | 35.116 |
| 7 | 150-175 | 21 | 0.04375 | 0.85625 | 175 | 0.132 | 28.277 |
| 8 | 175-200 | 18 | 0.03750 | 0.89375 | 200 | 0.095 | 16.732 |
| 9 | 200-225 | 18 | 0.03750 | 0.93125 | 225 | 0.067 | 6.397 |
| 10 | 225-250 | 10 | 0.02083 | 0.95208 | 250 | 0.047 | 7.156 |
| 11 | 250-275 | 7 | 0.01458 | 0.96667 | 275 | 0.033 | 4.966 |
| 12 | 275-300 | 8 | 0.01667 | 0.98333 | 300 | 0.023 | 0.830 |
| 13 | 300-325 | 3 | 0.00625 | 0.98958 | 325 | 0.016 | 2.808 |
| 14 | 325-350 | 1 | 0.00208 | 0.99167 | 350 | 0.011 | 3.456 |
| 15 | 350-375 | 1 | 0.00208 | 0.99375 | 375 | 0.008 | 1.905 |
| 16 | 375-400 | 2 | 0.00417 | 0.99792 | 400 | 0.005 | 0.100 |
| 17 | >400 | 1 | 0.00208 | 1.00000 | 425 | 0.004 | 0.301 |

**Table 6: Calculations using Normal method for Monthly analysis**

| INTERVAL | RANGE | Ni | fs(Xi) | Fs(Xi) | X | Zi | F(X) | P(X) | $Xc^2$ |
|---|---|---|---|---|---|---|---|---|---|
| 1 | <25 | 227 | 0.47292 | 0.47292 | 25 | -0.75 | 0.23 | 0.23 | 129.39 |
| 2 | 25-50 | 43 | 0.08958 | 0.56250 | 50 | -0.46 | 0.32 | 0.10 | 0.38 |
| 3 | 50-75 | 32 | 0.06667 | 0.62917 | 75 | -0.16 | 0.44 | 0.11 | 9.42 |
| 4 | 75-100 | 34 | 0.07083 | 0.70000 | 100 | 0.14 | 0.56 | 0.12 | 9.26 |
| 5 | 100-125 | 23 | 0.04792 | 0.74792 | 125 | 0.44 | 0.67 | 0.11 | 18.53 |
| 6 | 125-150 | 31 | 0.06458 | 0.81250 | 150 | 0.74 | 0.77 | 0.10 | 5.77 |
| 7 | 150-175 | 21 | 0.04375 | 0.85625 | 175 | 1.04 | 0.85 | 0.08 | 7.50 |
| 8 | 175-200 | 18 | 0.03750 | 0.89375 | 200 | 1.34 | 0.91 | 0.06 | 3.49 |
| 9 | 200-225 | 18 | 0.03750 | 0.93125 | 225 | 1.64 | 0.95 | 0.04 | 0.04 |
| 10 | 225-250 | 10 | 0.02083 | 0.95208 | 250 | 1.94 | 0.97 | 0.02 | 0.28 |
| 11 | 250-275 | 7 | 0.01458 | 0.96667 | 275 | 2.24 | 0.99 | 0.01 | 0.01 |
| 12 | 275-300 | 8 | 0.01667 | 0.98333 | 300 | 2.54 | 0.99 | 0.01 | 5.39 |
| 13 | 300-325 | 3 | 0.00625 | 0.98958 | 325 | 2.84 | 1.00 | 0.00 | 0.82 |
| 14 | 325-350 | 1 | 0.00208 | 0.99167 | 350 | 3.14 | 1.00 | 0.00 | 0.03 |
| 15 | 350-375 | 1 | 0.00208 | 0.99375 | 375 | 3.44 | 1.00 | 0.00 | 0.98 |
| 16 | 375-400 | 2 | 0.00417 | 0.99792 | 400 | 3.74 | 1.00 | 0.00 | 19.50 |
| 17 | >400 | 1 | 0.00208 | 1.00000 | 425 | 4.04 | 1.00 | 0.00 | 11.31 |

**B. Seasonal rainfall analysis**

The weekly precipitation data are divided into the moonsoon of South-West (June to September) and North-East (October to December). These are distributed in several intervals with a span of 25 mm and the incidence frequency is discovered to turn the usual information into a clustered data. The calculations using Weibull method for SW monsoon and NE monsoon are shown in Table 7 and Table 8. The estimation using the Gumbe method for SW monsoon and NE monsoon is shown in Table 9 and Table 10. The estimate is shown in Table 11 and Table 12 using Normal Method for SW Monsoon and NE Monsoon.

**Table 7: Calculations Using Weibull method for SW monsoon**

| RANGE | RANK | Ni | fs(Xi) | Fs(Xi) | P(Xi) | $Xc^2$ |
|---|---|---|---|---|---|---|
| <25 | 17 | 0 | 0.0000 | 0.0000 | 0.944 | 151.11 |
| 25-50 | 16 | 2 | 0.0125 | 0.0125 | 0.889 | 138.25 |
| 50-75 | 15 | 9 | 0.0563 | 0.0688 | 0.833 | 115.94 |
| 75-100 | 14 | 26 | 0.1625 | 0.2313 | 0.778 | 77.88 |
| 100-125 | 13 | 16 | 0.1000 | 0.3313 | 0.722 | 85.77 |
| 125-150 | 12 | 27 | 0.1688 | 0.5000 | 0.667 | 59.50 |
| 150-175 | 11 | 18 | 0.1125 | 0.6125 | 0.611 | 65.09 |
| 175-200 | 10 | 17 | 0.1063 | 0.7188 | 0.556 | 58.14 |
| 200-225 | 9 | 17 | 0.1063 | 0.8250 | 0.500 | 49.61 |
| 225-250 | 8 | 7 | 0.0438 | 0.8688 | 0.444 | 57.80 |
| 250-275 | 7 | 7 | 0.0438 | 0.9125 | 0.389 | 49.01 |
| 275-300 | 6 | 6 | 0.0375 | 0.9500 | 0.333 | 42.01 |
| 300-325 | 5 | 3 | 0.0188 | 0.9688 | 0.278 | 38.65 |
| 325-350 | 4 | 1 | 0.0063 | 0.9750 | 0.222 | 33.58 |
| 350-375 | 3 | 1 | 0.0063 | 0.9813 | 0.167 | 24.70 |
| 375-400 | 2 | 2 | 0.0125 | 0.9938 | 0.111 | 14.00 |
| >400 | 1 | 1 | 0.0063 | 1.0000 | 0.056 | 7.00 |

**Table 8: Calculations Using Weibull method for NE monsoon**

| RANGE | RANK | Ni | fs(Xi) | Fs(Xi) | $Xc^2$ P(Xi) | |
|---|---|---|---|---|---|---|
| <25 | 12 | 62 | 0.51667 | 0.51667 | 0.923 | 21.47 |
| 25-50 | 11 | 17 | 0.14167 | 0.65833 | 0.846 | 70.38 |
| 50-75 | 10 | 14 | 0.11667 | 0.775 | 0.769 | 66.43 |
| 75-100 | 9 | 8 | 0.06667 | 0.84167 | 0.692 | 67.85 |
| 100-125 | 8 | 5 | 0.04167 | 0.88333 | 0.615 | 64.18 |
| 125-150 | 7 | 4 | 0.03333 | 0.91667 | 0.538 | 56.86 |
| 150-175 | 6 | 3 | 0.025 | 0.94167 | 0.462 | 49.55 |
| 175-200 | 5 | 1 | 0.00833 | 0.95 | 0.385 | 44.18 |
| 200-225 | 4 | 1 | 0.00833 | 0.95833 | 0.308 | 34.95 |
| 225-250 | 3 | 3 | 0.025 | 0.98333 | 0.231 | 22.02 |
| 250-275 | 2 | 0 | 0 | 0.98333 | 0.154 | 18.46 |
| 275-300 | 1 | 2 | 0.01667 | 1 | 0.077 | 5.66 |

**Table 9: Calculations using Gumbel Method for SW monsoon**

| RANGE | RANK | Ni | fs(Xi) | Fs(Xi) | P(X) | $Xc^2$ |
|---|---|---|---|---|---|---|
| <25 | 17 | 0 | 0.0000 | 0.0000 | 0.0049 | 0.7824 |
| 25-50 | 16 | 2 | 0.0125 | 0.0125 | 0.0397 | 2.9847 |
| 50-75 | 15 | 9 | 0.0563 | 0.0688 | 0.1356 | 7.4359 |
| 75-100 | 14 | 26 | 0.1625 | 0.2313 | 0.2625 | 6.0909 |
| 100-125 | 13 | 16 | 0.1000 | 0.3313 | 0.3499 | 28.5513 |
| 125-150 | 12 | 27 | 0.1688 | 0.5000 | 0.3653 | 16.9205 |
| 150-175 | 11 | 18 | 0.1125 | 0.6125 | 0.3250 | 22.2258 |
| 175-200 | 10 | 17 | 0.1063 | 0.7188 | 0.2603 | 14.5819 |
| 200-225 | 9 | 17 | 0.1063 | 0.8250 | 0.1946 | 6.4144 |
| 225-250 | 8 | 7 | 0.0438 | 0.8688 | 0.1390 | 10.4485 |
| 250-275 | 7 | 7 | 0.0438 | 0.9125 | 0.0965 | 4.6078 |
| 275-300 | 6 | 6 | 0.0375 | 0.9500 | 0.0656 | 1.9289 |
| 300-325 | 5 | 3 | 0.0188 | 0.9688 | 0.0441 | 2.3300 |
| 325-350 | 4 | 1 | 0.0063 | 0.9750 | 0.0294 | 2.9123 |
| 350-375 | 3 | 1 | 0.0063 | 0.9813 | 0.0195 | 1.4349 |
| 375-400 | 2 | 2 | 0.0125 | 0.9938 | 0.0128 | 0.0015 |
| >400 | 1 | 1 | 0.0063 | 1.0000 | 0.0085 | 0.0925 |

**Table 10: Calculations Using Gumbel method for NE monsoon**

| RANGE | RANK | Ni | fs(Xi) | Fs(Xi) | P(X) | $Xc^2$ |
|---|---|---|---|---|---|---|
| <25 | 12 | 62 | 0.51667 | 0.51667 | 0.3559 | 8.7110 |
| 25-50 | 11 | 17 | 0.14167 | 0.65833 | 0.3564 | 15.5252 |
| 50-75 | 10 | 14 | 0.11667 | 0.77500 | 0.2911 | 12.5404 |
| 75-100 | 9 | 8 | 0.06667 | 0.84167 | 0.2103 | 11.7747 |
| 100-125 | 8 | 5 | 0.04167 | 0.88333 | 0.1412 | 8.4188 |
| 125-150 | 7 | 4 | 0.03333 | 0.91667 | 0.0907 | 4.3526 |
| 150-175 | 6 | 3 | 0.02500 | 0.94167 | 0.0567 | 2.1285 |
| 175-200 | 5 | 1 | 0.00833 | 0.95000 | 0.0349 | 2.4281 |
| 200-225 | 4 | 1 | 0.00833 | 0.95833 | 0.0213 | 0.9456 |
| 225-250 | 3 | 3 | 0.02500 | 0.98333 | 0.0129 | 1.3616 |
| 250-275 | 2 | 0 | 0.00000 | 0.98333 | 0.0078 | 0.9352 |
| 275-300 | 1 | 2 | 0.01667 | 1.00000 | 0.0047 | 3.6596 |

**Table 11: Calculations using Normal method for SW monsoon**

| RANGE | RANK | Ni | fs(Xi) | Fs(Xi) | Zi | F(X) | P(Xi) | $Xc^2$ |
|---|---|---|---|---|---|---|---|---|
| <25 | 17 | 0 | 0.0000 | 0.0000 | -2.0369 | 0.0234 | 0.0234 | 3.7387 |
| 25-50 | 16 | 2 | 0.0125 | 0.0125 | -1.7002 | 0.0476 | 0.0243 | 0.9133 |
| 50-75 | 15 | 9 | 0.0563 | 0.0688 | -1.3635 | 0.0895 | 0.0418 | 0.7930 |
| 75-100 | 14 | 26 | 0.1625 | 0.2313 | -1.0268 | 0.1545 | 0.0650 | 23.4235 |
| 100-125 | 13 | 16 | 0.1000 | 0.3313 | -0.6902 | 0.2457 | 0.0912 | 0.1349 |
| 125-150 | 12 | 27 | 0.1688 | 0.5000 | -0.3535 | 0.3618 | 0.1161 | 3.8184 |
| 150-175 | 11 | 18 | 0.1125 | 0.6125 | -0.0168 | 0.4934 | 0.1316 | 0.4421 |
| 175-200 | 10 | 17 | 0.1063 | 0.7188 | 0.3198 | 0.6255 | 0.1321 | 0.8110 |
| 200-225 | 9 | 17 | 0.1063 | 0.8250 | 0.6565 | 0.7438 | 0.1183 | 0.1965 |
| 225-250 | 8 | 7 | 0.0438 | 0.8688 | 0.9932 | 0.8378 | 0.0940 | 4.2943 |
| 250-275 | 7 | 7 | 0.0438 | 0.9125 | 1.3298 | 0.9054 | 0.0676 | 1.3468 |
| 275-300 | 6 | 6 | 0.0375 | 0.9500 | 1.6665 | 0.9493 | 0.0440 | 0.1522 |
| 300-325 | 5 | 3 | 0.0188 | 0.9688 | 2.0032 | 0.9751 | 0.0257 | 0.3018 |
| 325-350 | 4 | 1 | 0.0063 | 0.9750 | 2.3399 | 0.9886 | 0.0135 | 0.6285 |
| 350-375 | 3 | 1 | 0.0063 | 0.9813 | 2.6765 | 0.9951 | 0.0065 | 0.0014 |
| 375-400 | 2 | 2 | 0.0125 | 0.9938 | 3.0132 | 0.9980 | 0.0029 | 5.1320 |
| >400 | 1 | 1 | 0.0063 | 1.0000 | 3.3499 | 0.9992 | 0.0012 | 3.3535 |

**Table 12: Calculations Using Normal method for NE monsoon**

| RANGE | RANK | Ni | fs(Xi) | Fs(Xi) | Zi | F(Xi) | P(Xi) | $Xc^2$ |
|---|---|---|---|---|---|---|---|---|
| <25 | 12 | 62 | 0.51667 | 0.51667 | -0.6467 | 0.2593 | 0.2593 | 30.6380 |
| 25-50 | 11 | 17 | 0.14167 | 0.65833 | -0.2404 | 0.4051 | 0.1457 | 0.0137 |
| 50-75 | 10 | 14 | 0.11667 | 0.77500 | 0.1659 | 0.5657 | 0.1606 | 1.4424 |
| 75-100 | 9 | 8 | 0.06667 | 0.84167 | 0.5722 | 0.7162 | 0.1505 | 5.6065 |
| 100-125 | 8 | 5 | 0.04167 | 0.88333 | 0.9785 | 0.8342 | 0.1180 | 5.9247 |
| 125-150 | 7 | 4 | 0.03333 | 0.91667 | 1.3847 | 0.9140 | 0.0798 | 3.2485 |
| 150-175 | 6 | 3 | 0.02500 | 0.94167 | 1.7910 | 0.9606 | 0.0466 | 1.2025 |
| 175-200 | 5 | 1 | 0.00833 | 0.95000 | 2.1973 | 0.9840 | 0.0233 | 1.1575 |
| 200-225 | 4 | 1 | 0.00833 | 0.95833 | 2.6036 | 0.9941 | 0.0101 | 0.0370 |
| 225-250 | 3 | 3 | 0.02500 | 0.98333 | 3.0099 | 0.9980 | 0.0039 | 13.8282 |
| 250-275 | 2 | 0 | 0.00000 | 0.98333 | 3.4161 | 0.9993 | 0.0014 | 0.1637 |
| 275-300 | 1 | 2 | 0.01667 | 1.00000 | 3.8224 | 0.9998 | 0.0005 | 68.8990 |

**Table. 13 Chi square values for monthly, south-west monsoon and north-east monsoon analysis**

| DESCRIPTION | CHI-SQUARE VALUE | | |
|---|---|---|---|
| | Monthly analysis | South West monsoon | North East monsoon |
| WEIBULL | 3253.588 | 1068.052 | 521.998 |
| GUMBEL | **222.091** | 129.744 | **72.781** |
| NORMAL | 496.635 | **49.481** | 132.161 |

Table 13 shows that the standard distribution is considered to be the best fit with the least chi-square value for monthly analysis in Warangal. Normal distribution is found to fit best with the least Chi-Square value for southwest monsoon research in Warangal. Gumbel distribution is found to fit best with the least Chi-Square value for north-eastern monsoon study in Warangal.

**C. Crop planning**

An average effective rainfall for 40 years is shown in Table 14. The effective precipitation in the months of June, July, August, September and October is found to be higher. Whereas in the months of January, February, March and December, the total effective precipitation is zero. The preparation of the crop is based on the successful rainfall shown in Table 14.

Different crop water requirements are found (Arvind et al. 2017) and shown in Table 15. These are linked to the effective rainfall, estimated from the data on rainfall. Effective rainfall is the amount of rainfall that the crops actually use. We calculate the effective rainfall in the study area

$R_e = 0.8*P-25$, if $P \geq 75$mm

$R_e = 0.6*P-10$, if $P < 75$mm

Where,

Re is the effective rainfall (mm)

P is the total monthly rainfall(mm)

**Table 14 : Average Effective Rainfall for 40 years**

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average Rainfall(mm) | 0 | 0 | 0 | 0.88 | 7.35 | 70.21 | 125.14 | 122.47 | 107.41 | 62.45 | 7.98 | 0 |

A Warangal study reported that 471,000 hectares are grown each year, of which 138,900 hectares are sown more than once, resulting in a gross cultivated area of 609,800 hectares. 323,900 hectares (68.8%) are irrigated and the remaining crops are rainfed.

At the time, rice is the largest crop, accounting for 198,000 hectares per year (32.5 percent of the gross crop area). Nearly all rice cultivation is irrigated in Warangal. The next biggest crop is cotton, planted on 158,700 hectares (26% of the crop area). Overall, farmers grow grain (mostly rice and maize with some sorghum) on 287,000 hectares (47.1% of the gross crop area), pulses and legumes (groundnut, green gram, red gram, bajra and bengal gram) on 104,300 hectares (17.1% of the gross crop area), and horticultural crops (mostly chilies, some turmeric) on 33,400 hectares (5.5% of the gross crop area). Only 39.7% of cotton is irrigated and the rest is rainfed. The average yield of cotton is 438 kg / hectares.

**Table 15. Crop Planning For Warangal District**

| Crops | No. Of Days | TWR (mm) | Rainfed (mm) | Irrigated (mm) | Sowing | Harvesting |
|---|---|---|---|---|---|---|
| Paddy | 120 | 1200 | 300 | 900 | August | December |
| Cotton | 165 | 600 | 425 | 175 | June(mid) | March |
| Maize | 100 | 500 | 425 | 75 | June(mid) | December |
| Mirchi | 170 | 1000 | 300 | 700 | August | February |
| Banana | 270 | 900 | 504 | 396 | Feb(mid) | November |
| Turmeric | 300 | 980 | 426 | 554 | July | April |
| Wheat | 90 | 800 | 300 | 500 | November | April |

For all the plants, TWR is given in Table 15. The average rainfall is excluded from the total water demand to receive the irrigated amount of water and the average rainfall is the amount of water supplied by the rain. Time of seeding and time for harvesting are decided on the basis of rain and also by consulting the farmers.

**D. Economic analysis**

Yield before the crop Economic analysis is carried out by comparing yield before planning of crops and after planning of crops is shown in Table 16. Yield before crop planning was taken from farmers who have been rising in the Warangal area for the past 15 years. Yield after crop planning was taken through consultation with farmers and also from the Statistics and Program Implementation Ministry website. The crop prices are taken from the market in Warangal and the percentage of gain has been determined. Economic analysis reveals that overall profit rises in the study area as a result of new crop preparation.

**Table 16 : Economic Analysis**

| Crops | Rate(Rs) Per quintal | Yield in quintals per acre(before crop planning) | Yield in quintals per acre(after crop planning) | Profit (Rs) | Profit in % |
|---|---|---|---|---|---|
| Paddy | 1800 | 21 | 25 | 7200 | 19.0 |
| Cotton | 4550 | 12 | 15 | 13650 | 25.0 |
| Maize | 1440 | 40 | 45 | 7200 | 12.5 |
| Mirchi | 8000 | 25 | 30 | 40000 | 17.0 |
| Banana | 1000 | 200 | 250 | 50000 | 25.0 |
| Turmeric | 6000 | 20 | 25 | 30000 | 25.0 |
| Wheat | 4500 | 6 | 8 | 9000 | 33.3 |

## V. CONCLUSION

From the analysis it can be inferred that the best distribution for monthly rainfall analysis and for North-East seasonal rainfall analysis is Gumbel Distribution (Extreme Value Type-1). The best distribution for the South-West seasonal precipitation study was considered to be normal distribution. For the Kharif season, crops such as Cotton, Maize, Paddy, Mirchi, Turmericand Banana are suggested. For the Rabi season, crops such as wheat, maize, watermelon and paddy are suggested. The economic analysis for the crops was conducted and the overall profit for the crops grown is 23 percent per acre.

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