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# A Fuzzy Log-Normal Distribution Model for the Rainfall level of Namakkal District

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**Abstract:**

Models of mathematics can accurately and precisely obtain solutions to many complex unsolvable problems in all fields. In this paper using a few mathematical models we can take the rainfall levels in Namakkal district from 2014 to 2018 and find the highest rainfall year by the fuzzy mean and the fuzzy variance in the Log-Normal distribution.

**Keywords:** Log - Normal distribution, Mean, Variance, Mathematical Modelling, Fuzzy Set

**2010 AMS subject classification**: 01-06, 62E10, 62E86, 97M10.

## 1. Introduction

A model may help to explain a system and to study the effect of different components, and to make predictions about behavior [1].The Namakkal area is referred to as 'Thiruvaraikkal' in the inscriptions on the north-western and southern walls of the Paladaina temple located on the hill. Namakkal is also known as the 'City of Chickens' and the 'Egg City' as the eggs sent to most parts of the country is produced in Namakkal. Namakkaldistrict was separated from Salem district and emerged as a separate district from 01.01.1997. In Namakkal district, there are eight circles namely Namakkal, Rasipuram, Kollimalai, Chenthamangalam, Paramathi Vellore, Tiruchengode, Kumarapalayam and Mohanur. Namakkal district is bounded on the north by Salem district, on the south by Karur district, on the east by Trichy and Salem districts and on the west by Erode district. According to the 2011 census, the population of Namakkal district is 17, 26,601. This includes 8, 69,280 males and 8, 57,321 females [6]. Some authors [2, 3, 4] instructed with some distributions in their books.

The geographical area of Namakkal district is 3368.21 sq. Km. Is. The district is located between 11.00 ′ and 11.360 ′ north latitude and 77.28′ and 78.300′ east longitude.The main waterfalls of the district are Kaviriyaru, Ayyaru, Karippottan River and Thirumanimuttaru. Of these, the Cauvery River flows in a south-southwesterly direction, bordering the district. The famous Cauvery River

flows through the Paramathi Vellore Circle. Thus irrigated lands are located in Paramathi and Mohanur Unions.

Agriculture continues to be an important part of the economy of the district. 70% of the people are engaged in agriculture and its related occupations as their livelihood. The total area of the district is 3363.35 sq km. The total crop area is 3.367 lakh hectares. Sustainable agricultural production, increasing productivity in sustainable agriculture, meeting the demand for food in line with the growing population, meeting the demand for raw materials for agro-based industries and providing employment to the rural population have always been key principles and principles. The total geographical area of Namakkal district is 3, 36,719 hectares. Of this, the area under net crop cultivation is 1, 41,537 hectares. Of these, 60,939 hectares are irrigated. The remaining 80,598 hectares are irrigated area. The Pallipalayam area is irrigated on an area of 4585 hectares through the Mato East Coast Canal. The average annual rainfall is 716.54 mm [5]. Due to the cultivation of various crops in Namakkal district, agriculture is the main occupation of the people of this district. The district receives rainfall in all seasons. Most rainfall, however, is available through the northeast monsoon. Syamala et. al [7, 8, 9, 10] discussed about some fuzzy concepts.

In this paper, we can find out about calculating the maximum rainfall year in Namakkal district by using fuzzy mean and the fuzzy variance in the Log-Normal distribution using mathematical models with rainfall patterns for 2014-2018.

## 2. Fuzzy Log-Normal Distribution

One way to quality a random variable follows a log-normal distribution is to say that its logarithm is normally distributed [4]. The p.d.f of log-normal distribution is given by

$$f(n;\mu,\sigma) = \frac{1}{n\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{In\, n-\mu}{\sigma}\right)^2}$$

where the variable n> 0 and the parameter μ and σ > 0 all are real numbers.

It is sometimes denoted $\Lambda(\mu, \sigma^2)$ in the same spirit as we often a normally distributed variable by $N(\mu, \sigma^2)$ [2]. The c.d.f of the log-normal distribution is given by

$$F(n) = \frac{1}{\sigma\sqrt{2\pi}} \int_0^n \frac{1}{t} e^{-\frac{1}{2}\left(\frac{In\, n-\mu}{\sigma}\right)^2} dt$$

The mean of the log-normal distribution is given by $\mu_k^1 = E(n^k) = e^{k\mu+\frac{k^2\sigma^2}{2}}$

The $\alpha$ cut of fuzzy mean is $\bar{E}(n) = \{\bar{E}_l(n), \bar{E}_u(n)\}$

where $\bar{E}_l(n) = \min\left\{e^{\bar{\mu}+\frac{\bar{\sigma}^2}{2}}\right\}$ and $\bar{E}_u(n) = \max\left\{e^{\bar{\mu}+\frac{\bar{\sigma}^2}{2}}\right\}$.

The $\alpha$ cut of fuzzy variance is $\bar{V}(n) = \{\bar{V}_l(n), \bar{V}_u(n)\}$

where $\bar{V}_l(n) = \min\left\{e^{2\bar{\mu}+\bar{\sigma}^2}(e^{\bar{\sigma}^2}-1)\right\}$ and $\bar{V}_u(n) = \max\left\{e^{2\bar{\mu}+\bar{\sigma}^2}(e^{\bar{\sigma}^2}-1)\right\}$.

## 3. Application

Let us take the Namakkal district rainfall levels from 2014 to 2018 [3].

Table.3.ARainfall levels for 2014

| Months | Jan | Feb | Mar | April | May | June | July | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainfall levels (mm) | 0 | 0.6 | 0 | 21.4 | 96.2 | 35.7 | 34.8 | 67.3 | 81.9 | 195.5 | 44.8 | 11.3 |

Table.3.B Rainfall levels for 2015

| Months | Jan | Feb | Mar | April | May | June | July | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainfall levels (mm) | 24.5 | 1.1 | 2.7 | 107.8 | 75.4 | 45.2 | 23.6 | 65.7 | 164.3 | 115 | 162.3 | 31.9 |

Table.3.C Rainfall levels for 2016

| Months | Jan | Feb | Mar | April | May | June | July | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainfall levels (mm) | 0 | 0 | 0 | 5.3 | 85.6 | 35.4 | 125.2 | 49.4 | 31.3 | 24.2 | 7.4 | 25.9 |

Table.3.D Rainfall levels for 2017

| Months | Jan | Feb | Mar | April | May | June | July | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainfall levels (mm) | 6.3 | 0 | 16.8 | 26.9 | 98 | 24 | 45.1 | 115.2 | 194.8 | 149.8 | 43.6 | 63.1 |

Table.3.E Rainfall levels for 2018

| Months | Jan | Feb | Mar | April | May | June | July | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainfall levels (mm) | 0 | 26.8 | 14 | 13.6 | 155.8 | 33.2 | 41.5 | 61.1 | 120.9 | 106.5 | 63.7 | 12.4 |

## 4. Results

The double parameter of the log-normal distribution for Table.3.A is

$\sigma = 0.57667$, $\mu = 4.1952$.

Let the matching fuzzy triangular numbers are

$\bar{\sigma}$ = [0.34547, 0.57667, 0.80787] and $\bar{\mu}$ = [3.7415, 4.1952, 4.6489]

and the matching α- cut are given by

$\bar{\sigma}$= [0.34547 + 0.2312α, 0.80787 – 0.2312α] and

$\bar{\mu}$ = [3.7415 + 0.4537α, 4.6489 – 0.4537α]

Table 4.A Fuzzy Mean and variance value for lower and upper alpha values

| α | low σ | low μ | up σ | up μ | $E_l(x)$ | $E_u(x)$ | $V_l(x)$ | $V_u(x)$ |
|---|---|---|---|---|---|---|---|---|
| 0 | 0.34547 | 3.7415 | 0.80787 | 4.6489 | 44.75373 | 144.7817 | 253.8945 | 19298.03 |
| 0.1 | 0.36859 | 3.78687 | 0.78475 | 4.60353 | 47.21914 | 135.8357 | 324.458 | 15705.73 |
| 0.2 | 0.39171 | 3.83224 | 0.76163 | 4.55816 | 49.847 | 127.5107 | 412.0517 | 12782.51 |
| 0.3 | 0.41483 | 3.87761 | 0.73851 | 4.51279 | 52.64925 | 119.7599 | 520.5086 | 10402.46 |
| 0.4 | 0.43795 | 3.92298 | 0.71539 | 4.46742 | 55.63876 | 112.5403 | 654.5131 | 8463.763 |
| 0.5 | 0.46107 | 3.96835 | 0.69227 | 4.42205 | 58.82946 | 105.8125 | 819.7913 | 6883.961 |
| 0.6 | 0.48419 | 4.01372 | 0.66915 | 4.37668 | 62.2364 | 99.54013 | 1023.346 | 5596.23 |
| 0.7 | 0.50731 | 4.05909 | 0.64603 | 4.33131 | 65.87584 | 93.68962 | 1273.746 | 4546.353 |
| 0.8 | 0.53043 | 4.10446 | 0.62291 | 4.28594 | 69.76539 | 88.23012 | 1581.479 | 3690.304 |
| 0.9 | 0.55355 | 4.14983 | 0.59979 | 4.24057 | 73.92409 | 83.13319 | 1959.391 | 2992.299 |
| 1 | 0.57667 | 4.1952 | 0.57667 | 4.1952 | 78.37258 | 78.37258 | 2423.228 | 2423.228 |

The double parameter of the log-normal distribution for Table.3.B is

$\sigma = 0.65456$, $\mu = 4.3452$.

Let the matching fuzzy triangular numbers are

$\bar{\sigma}$ = [0.42336, 0.65456, 0.88576] and $\bar{\mu}$ = [3.8915, 4.3452, 4.7989]

and the matching α- cut are given by

$\bar{\sigma}$= [0.42336 + 0.2312α, 0.88576 – 0.2312α] and

$\bar{\mu}$ = [3.8915 + 0.4537α, 4.7989 – 0.4537α]

Table 4.B Fuzzy Mean and variance value for lower and upper alpha values

| α | low σ | low μ | up σ | up μ | $E_l(x)$ | $E_u(x)$ | $V_l(x)$ | $V_u(x)$ |
|---|---|---|---|---|---|---|---|---|
| 0 | 0.42336 | 3.8915 | 0.88576 | 4.7989 | 53.57684 | 179.6814 | 563.4755 | 38466.97 |
| 0.1 | 0.44648 | 3.93687 | 0.86264 | 4.75353 | 56.63019 | 168.2757 | 707.4666 | 31279.98 |
| 0.2 | 0.4696 | 3.98224 | 0.83952 | 4.70816 | 59.88955 | 157.6783 | 884.9611 | 25444.96 |
| 0.3 | 0.49272 | 4.02761 | 0.8164 | 4.66279 | 63.37038 | 147.8273 | 1103.46 | 20704.03 |
| 0.4 | 0.51584 | 4.07298 | 0.79328 | 4.61742 | 67.08936 | 138.6658 | 1372.141 | 16849.36 |
| 0.5 | 0.53896 | 4.11835 | 0.77016 | 4.57205 | 71.06457 | 130.1416 | 1702.243 | 13713.31 |
| 0.6 | 0.56208 | 4.16372 | 0.74704 | 4.52668 | 75.31558 | 122.2068 | 2107.535 | 11160.47 |
| 0.7 | 0.5852 | 4.20909 | 0.72392 | 4.48131 | 79.86355 | 114.8171 | 2604.894 | 9081.355 |
| 0.8 | 0.60832 | 4.25446 | 0.7008 | 4.43594 | 84.73143 | 107.9319 | 3215.026 | 7387.357 |
| 0.9 | 0.63144 | 4.29983 | 0.67768 | 4.39057 | 89.94409 | 101.5138 | 3963.351 | 6006.681 |
| 1 | 0.65456 | 4.3452 | 0.65456 | 4.3452 | 95.52848 | 95.52848 | 4881.101 | 4881.101 |

The double parameter of the log-normal distribution for Table.3.C is

σ = 1.0416, μ = 3.9543.

Let the matching fuzzy triangular numbers are

$\bar{\sigma}$ = [0.8104, 1.0416, 1.2728] and $\bar{\mu}$ = [3.5006, 3.9543, 4.4070]

and the matching α- cut are given by

$\bar{\sigma}$= [0.8104 + 0.2312α, 1.2728 – 0.2312α] and

$\bar{\mu}$ = [3.5006 + 0.4537α, 4.4070 – 0.4537α]

Table 4.C Fuzzy Mean and variance value for lower and upper alpha values

| α | low σ | low μ | up σ | up μ | $E_l(x)$ | $E_u(x)$ | $V_l(x)$ | $V_u(x)$ |
|---|---|---|---|---|---|---|---|---|
| 0 | 0.8104 | 3.5006 | 1.2728 | 4.408 | 46.01531 | 184.5665 | 1966.037 | 138071.1 |
| 0.1 | 0.83352 | 3.54597 | 1.24968 | 4.36263 | 49.0749 | 171.3109 | 2416.1 | 110549.4 |
| 0.2 | 0.85664 | 3.59134 | 1.22656 | 4.31726 | 52.36592 | 159.0923 | 2969.923 | 88628.67 |
| 0.3 | 0.87976 | 3.63671 | 1.20344 | 4.27189 | 55.90752 | 147.8242 | 3651.929 | 71144.36 |
| 0.4 | 0.90288 | 3.68208 | 1.18032 | 4.22652 | 59.72055 | 137.4277 | 4492.455 | 57179.18 |
| 0.5 | 0.926 | 3.72745 | 1.1572 | 4.18115 | 63.82775 | 127.8306 | 5529.222 | 46009.63 |
| 0.6 | 0.94912 | 3.77282 | 1.13408 | 4.13578 | 68.25389 | 118.9673 | 6809.197 | 37064.2 |
| 0.7 | 0.97224 | 3.81819 | 1.11096 | 4.09041 | 73.02598 | 110.7778 | 8390.929 | 29890.69 |
| 0.8 | 0.99536 | 3.86356 | 1.08784 | 4.04504 | 78.1735 | 103.2071 | 10347.5 | 24130.86 |
| 0.9 | 1.01848 | 3.90893 | 1.06472 | 3.99967 | 83.72861 | 96.20529 | 12770.24 | 19500.42 |
| 1 | 1.0416 | 3.9543 | 1.0416 | 3.9543 | 89.72642 | 89.72642 | 15773.46 | 15773.46 |

The double parameter of the log-normal distribution for Table.3.D is

σ = 0.70643, μ = 4.3393.

Let the matching fuzzy triangular numbers are

$\bar{\sigma}$ = [0.47523, 0.70643, 0.93763] and $\bar{\mu}$ = [3.8856, 4.3393, 4.7930]

and the matching α- cut are given by

$\bar{\sigma}$= [0.47523 + 0.2312α, 0.93763 – 0.2312α] and

$\bar{\mu}$ = [3.8856 + 0.4537α, 4.7930 – 0.4537α]

Table 4.D Fuzzy Mean and variance value for lower and upper alpha values

| α | low σ | low μ | up σ | up μ | $E_l(x)$ | $E_u(x)$ | $V_l(x)$ | $V_u(x)$ |
|---|---|---|---|---|---|---|---|---|
| 0 | 0.47523 | 3.8856 | 0.93763 | 4.793 | 54.5175 | 187.2744 | 753.0841 | 49410.82 |
| 0.1 | 0.49835 | 3.93097 | 0.91451 | 4.74763 | 57.69361 | 175.1765 | 938.3589 | 40134.62 |
| 0.2 | 0.52147 | 3.97634 | 0.89139 | 4.70226 | 61.08739 | 163.9478 | 1166.133 | 32617.59 |
| 0.3 | 0.54459 | 4.02171 | 0.86827 | 4.65689 | 64.7154 | 153.5209 | 1445.926 | 26520.79 |
| 0.4 | 0.56771 | 4.06708 | 0.84515 | 4.61152 | 68.59553 | 143.8339 | 1789.403 | 21571.84 |
| 0.5 | 0.59083 | 4.11245 | 0.82203 | 4.56615 | 72.74717 | 134.8303 | 2210.864 | 17551.54 |
| 0.6 | 0.61395 | 4.15782 | 0.79891 | 4.52078 | 77.19134 | 126.4578 | 2727.856 | 14283.33 |
| 0.7 | 0.63707 | 4.20319 | 0.77579 | 4.47541 | 81.9508 | 118.6686 | 3361.928 | 11624.8 |
| 0.8 | 0.66019 | 4.24856 | 0.75267 | 4.43004 | 87.05024 | 111.4188 | 4139.556 | 9460.951 |
| 0.9 | 0.68331 | 4.29393 | 0.72955 | 4.38467 | 92.51643 | 104.6678 | 5093.308 | 7698.846 |
| 1 | 0.70643 | 4.3393 | 0.70643 | 4.3393 | 98.37844 | 98.37844 | 6263.272 | 6263.272 |

The double parameter of the log-normal distribution for Table.3.E is

σ = 0.52939, μ = 4.2867.

Let the matching fuzzy triangular numbers are

$\bar{\sigma}$ = [0.29819, 0.52939, 0.76059] and $\bar{\mu}$ = [3.8330, 4.2867, 4.7404]

and the matching α- cut are given by

$\bar{\sigma}$= [0.29819 + 0.2312α, 0.76059 – 0.2312α] and

$\bar{\mu}$ = [3.8330 + 0.4537α, 4.7404 – 0.4537α]

Table 4.E Fuzzy Mean and variance value for lower and upper alpha values

| α | low σ | low μ | up σ | up μ | $E_l(x)$ | $E_u(x)$ | $V_l(x)$ | $V_u(x)$ |
|---|---|---|---|---|---|---|---|---|
| 0 | 0.29819 | 3.833 | 0.76059 | 4.7404 | 48.30131 | 152.8793 | 216.9477 | 18308.66 |
| 0.1 | 0.32131 | 3.87837 | 0.73747 | 4.69503 | 50.90647 | 143.5899 | 281.842 | 14899.57 |
| 0.2 | 0.34443 | 3.92374 | 0.71435 | 4.64966 | 53.68083 | 134.937 | 362.9574 | 12122.59 |
| 0.3 | 0.36755 | 3.96911 | 0.69123 | 4.60429 | 56.63666 | 126.8734 | 463.9738 | 9859.662 |
| 0.4 | 0.39067 | 4.01448 | 0.66811 | 4.55892 | 59.7872 | 119.3554 | 589.3857 | 8015.078 |
| 0.5 | 0.41379 | 4.05985 | 0.64499 | 4.51355 | 63.14673 | 112.3429 | 744.6849 | 6511.193 |
| 0.6 | 0.43691 | 4.10522 | 0.62187 | 4.46818 | 66.7307 | 105.799 | 936.5822 | 5284.951 |
| 0.7 | 0.46003 | 4.15059 | 0.59875 | 4.42281 | 70.55579 | 99.68954 | 1173.281 | 4285.101 |
| 0.8 | 0.48315 | 4.19596 | 0.57563 | 4.37744 | 74.64003 | 93.9831 | 1464.815 | 3469.948 |
| 0.9 | 0.50627 | 4.24133 | 0.55251 | 4.33207 | 79.00291 | 88.65068 | 1823.457 | 2805.546 |
| 1 | 0.52939 | 4.2867 | 0.52939 | 4.2867 | 83.66552 | 83.66552 | 2264.233 | 2264.233 |

Table 4.F Fuzzy Mean value of the Rainfall levels for 2014 to 2018

| α | $E_l(x)$ | | | | | $E_u(x)$ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2014 | 2015 | 2016 | 2017 | 2018 | 2014 | 2015 | 2016 | 2017 | 2018 |
| 0 | 44.75373 | 53.57684 | 46.01531 | 54.5175 | 48.30131 | 144.7817 | 179.6814 | 184.5665 | 187.2744 | 152.8793 |
| 0.1 | 47.21914 | 56.63019 | 49.0749 | 57.69361 | 50.90647 | 135.8357 | 168.2757 | 171.3109 | 175.1765 | 143.5899 |
| 0.2 | 49.847 | 59.88955 | 52.36592 | 61.08739 | 53.68083 | 127.5107 | 157.6783 | 159.0923 | 163.9478 | 134.937 |
| 0.3 | 52.64925 | 63.37038 | 55.90752 | 64.7154 | 56.63666 | 119.7599 | 147.8273 | 147.8242 | 153.5209 | 126.8734 |
| 0.4 | 55.63876 | 67.08936 | 59.72055 | 68.59553 | 59.7872 | 112.5403 | 138.6658 | 137.4277 | 143.8339 | 119.3554 |
| 0.5 | 58.82946 | 71.06457 | 63.82775 | 72.74717 | 63.14673 | 105.8125 | 130.1416 | 127.8306 | 134.8303 | 112.3429 |
| 0.6 | 62.2364 | 75.31558 | 68.25389 | 77.19134 | 66.7307 | 99.54013 | 122.2068 | 118.9673 | 126.4578 | 105.799 |
| 0.7 | 65.87584 | 79.86355 | 73.02598 | 81.9508 | 70.55579 | 93.68962 | 114.8171 | 110.7778 | 118.6686 | 99.68954 |
| 0.8 | 69.76539 | 84.73143 | 78.1735 | 87.05024 | 74.64003 | 88.23012 | 107.9319 | 103.2071 | 111.4188 | 93.9831 |
| 0.9 | 73.92409 | 89.94409 | 83.72861 | 92.51643 | 79.00291 | 83.13319 | 101.5138 | 96.20529 | 104.6678 | 88.65068 |
| 1 | 78.37258 | 95.52848 | 89.72642 | 98.37844 | 83.66552 | 78.37258 | 95.52848 | 89.72642 | 98.37844 | 83.66552 |

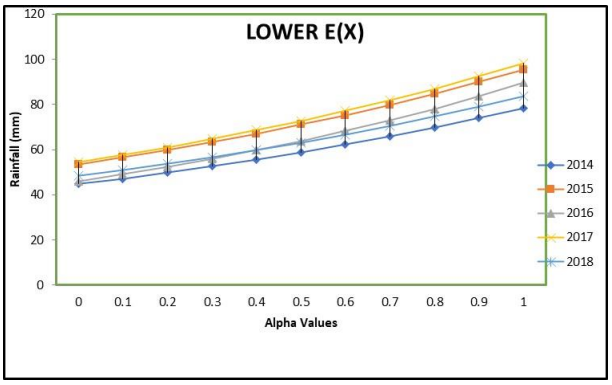


Fig.4.A Lower mean value of rainfall levels in 2014 - 2018

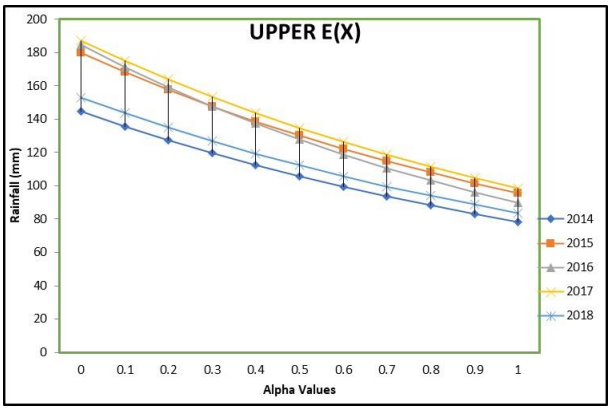


Fig.4.B Upper mean value of rainfall levels in 2014 - 2018

## 5. Conclusion

This paper gets the results through a mathematical model of rainfall levels in Namakkal district from 2014 to 2018. These results show that the alpha cut value continues to increase in the lower average and the alpha cut value decreases in the upper average. By this approach the conclusion holds that in 2017, Namakkal district received heavy rainfall.

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