Modeling Selected Climatic Variables in Ibadan, Oyo State, Nigeria using the Modified Generalized Burr Density Function

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Abstract

The aim of this study was fitting the modified generalized burr density function to total rainfall and temperature data obtained from the meteorological unit in the Department of Environmental Modelling and Management of the Forestry Research Institute of Nigeria (FRIN) in Ibadan, Oyo State, Nigeria. The choice of the density function was based on the positive skewness of the two climate series, a sufficient condition for the selection of the burr density. The Kolmogorov-Smirnov goodness of fit tests and the plots of the cumulative distribution function confirmed the adequacy of the density function to model adequately the two climate series as well as the estimates of the descriptive statistics from the original rainfall and temperature series that compared well with the ones obtained from the fitted burr density. The modified burr density function is therefore recommended to model skewed datasets of interest.

Keywords: Modified generalized burr density function, Positive skewness, Sufficient condition, Descriptive statistics, Ecosystem, Climate, Environmental changes

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Introduction

According to [1], Nigeria is a tropical nation with a population of more than 140,003,542 people and a land area of about 910,768km^2. It accounts for about twenty per cent of all Africans and stretches for about 1,200 km in the North-South and East-West directions and has a coastline of about 853 km long'. He further noted that 'temperature is high almost all the year round while rainfall which accounts for a considerable variation in the distribution of climatic types, seasonality, vegetation distribution and diversities in associated ecosystem varies significantly'. Adejuwon (2004 cited in [2]) noted that 'Nigerian Agriculture depends highly on climate because temperature, sunlight, water, and relative humidity are the main drivers of crop growth and yield'.

Therefore any adverse environmental change in Nigeria will have a significant negative impact on food production leading to food shortages.

[3] observed that 'understanding the spatial and temporary variations in climate within a zone or region, and their relationships with other factors like environmental planning, land-use planning, watershed management and territorial ordering, are important activities related to climate change and the management of the natural resources' .This remark is corroborated by [4] who opined that 'the importance of knowing the future climatic variation parameters cannot be under-estimated because knowledge and information on the climatic variation parameters in an environment is very vital for environmental study assessment and proper planning'. This is perhaps the foundation for worldwide interest in global warming implications and climate change analysis [5]. The effects of global warming, climate change and green house emissions have been observed by the following authors [6-10].

As observed by [11], 'a common problem in scientific enquiry is fitting a probability distribution to a set of observations for a variable. One does this to be able to make predictions about the future'. He continued by noting again that 'the principle behind fitting distributions to data is to find the type of distribution and the value of the parameters that give the highest probability of producing the observed data'. A literature search on climate data analysis in Nigeria revealed the use of some probability distributions to fit selected climate variables. Authors who have contributed along this line include [12-17]. A major criticism of these past studies is the fact that no valid justification was provided for the choice of probability functions fitted to available climate data. Also the use of discrete probability function to model continuous climate data without appropriate transformation is considered erroneous. This present study therefore is an attempt to correct these limitations by using the modified generalized burr density function. The generalized burr density function according to [18] is skewed and can be used to model many skewed real life data sets. Since the total rainfall and temperature data of Ibadan under consideration are skewed, the choice of this density function is considered appropriate for the study at hand.

2.0 The Modified Generalized Burr Density Function

[18] defined the generalized burr density function as

$$f(s)=\frac{p(\lambda)^{v-\frac{\mu}{p}}(\psi)^{\frac{\mu}{p}}s^{\mu-1}}{B\left(\frac{\mu}{p},v-\frac{\mu}{p}\right)\left(\lambda+\psi s^{p}\right)^{v}}, \text{ for } (s, \lambda, \psi, \mu, v, p)>0, \text{ and } v>\frac{\mu}{p} \qquad (1)$$

The modified generalized burr density function is obtained from the five-parameter probability density function in (1) by letting $S = \frac{W-\tau}{c}$. If that is the case, then $ds = \frac{dw}{c}$ and $g(w) = h(s = \xi(s))\left|\frac{ds}{dw}\right|$. The implication of the last expression is the fact that the density function of W will be given as:

$$g(w) = \frac{p(\lambda)^{v-\frac{\mu}{p}}(\psi)^{\frac{\mu}{p}}\left(\frac{w-\tau}{c}\right)^{\mu-1}}{B\left(\frac{\mu}{p}, v-\frac{\mu}{p}\right)\left(\lambda+\psi\left(\frac{w-\tau}{c}\right)^{p}\right)^{v}}\left(\frac{1}{c}\right) \quad (2)$$

In (2), let μ=p and further let λ=ψ =1 so that

$$g(w) = \frac{p\left(\frac{w-\tau}{c}\right)^{p-1}}{B(1, v-1)\left(1+\left(\frac{w-\tau}{c}\right)^{p}\right)^{v}}\left(\frac{1}{c}\right) = \frac{p\left(\frac{w-\tau}{c}\right)^{p-1}}{cB(1, v-1)\left(1+\left(\frac{w-\tau}{c}\right)^{p}\right)^{v}} \quad (3)$$

The density in (3) will be called the Modified Generalized Burr density function because instead of the initial five (λ, ψ, μ, v, & p) parameters in (1), there are only four (τ, c, v, & p) in (3). The modified density function is of practical importance because estimation of its parameters can be readily obtained through most advanced distribution fitting software.

4.0 Description of Study Area and Data

Ibadan, the capital of Oyo State, according to (Agbola and Olurin, 2000 cited in [19]) 'is situated in the south-west part of Nigeria on longitude 3^{o}54^{1} of the Greenwich Meridian and latitude 7^{o}54^{1} north of equator. The city is about 234 meters above sea level and it is located on gently rolling hills running in a northwest/southeast direction'. Also, [19] stated that by road, 'Ibadan is about 150km from Lagos, the commercial

nerve centre of Nigeria and enjoys the characteristic West African monsoon climate which has two major seasons (rain-March and October and dry-November and February)' .The dataset used in this study was the monthly total rainfall (mm) and maximum temperature (^{o}C) data recorded by the headquarters of the Forestry Research Institute of Nigeria (FRIN) located in Ibadan, Oyo-State, Nigeria. The data were obtained from the meteorological unit in the Department of Environmental Modeling and Management of the Forestry Research Institute of Nigeria (FRIN). The data cover sixteen years from 1995 to 2010. Other climate variables usually recorded by the institute include relative humidity, fire danger index, number of rainy days and maximum dry spell length.

4.0 Results and Discussion

The choice of the modified density function was corroborated by the estimates of the skewness for the two climate variables of rainfall and temperature. The skewness for each was 0.37639 and 0.20307 respectively; suggesting that the variables were positively skewed and this justifies the use of the burr density function. The Kolmogorov-Smirnov goodness of fit test (Table 1) at $\alpha = 5\%$ once more confirmed the adequacy of the density function. The P_{values} for the rainfall and temperature series were 0.46729 and 0.13604. In order to be fully convinced that the modified burr density function performed well for the present study, the cumulative distribution function graphs (Figures 1and 2) were also considered. The two graphs for the two series eliminated any doubt about the appropriateness of the density function. The estimates of the parameters (Table 2) of the modified generalized burr density function for the two series obtained from the Easy-Fit software were p =1.7027, c =659.43, δ = -4.5678 and v = 1731.3 for rainfall and p = 2.531, c = 44.719, δ = 26.416 and v = 2.265 for temperature. From these estimates, descriptive statistics were obtained from the fitted burr density for the two series (Table 3). The statistics (mean, standard deviation, coefficient of variation and skewness) obtained from the fitted density did not differ greatly from the ones obtained from the original data.

Table 1: Kolmogorov-Smirnov Goodness of Fit for the Modified Burr Density Function

Rainfall		**Temperature**	
K-S Statistic	P_{value}	K-S Statistic	P_{value}
0.06588	0.46729	0.09031	0.13604

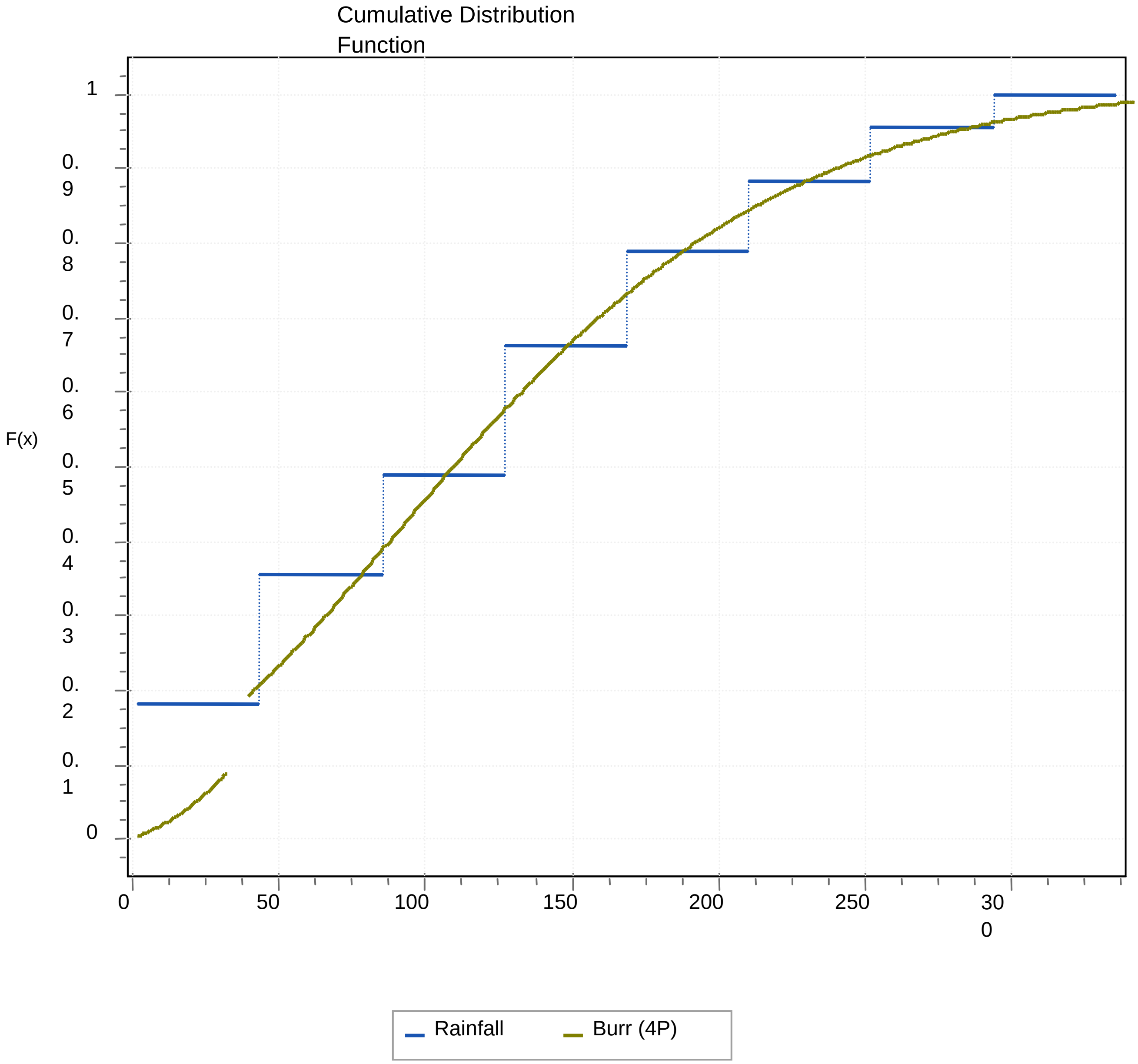

Figure 1: Cumulative Distribution Graph for the Burr Density (Rainfall)

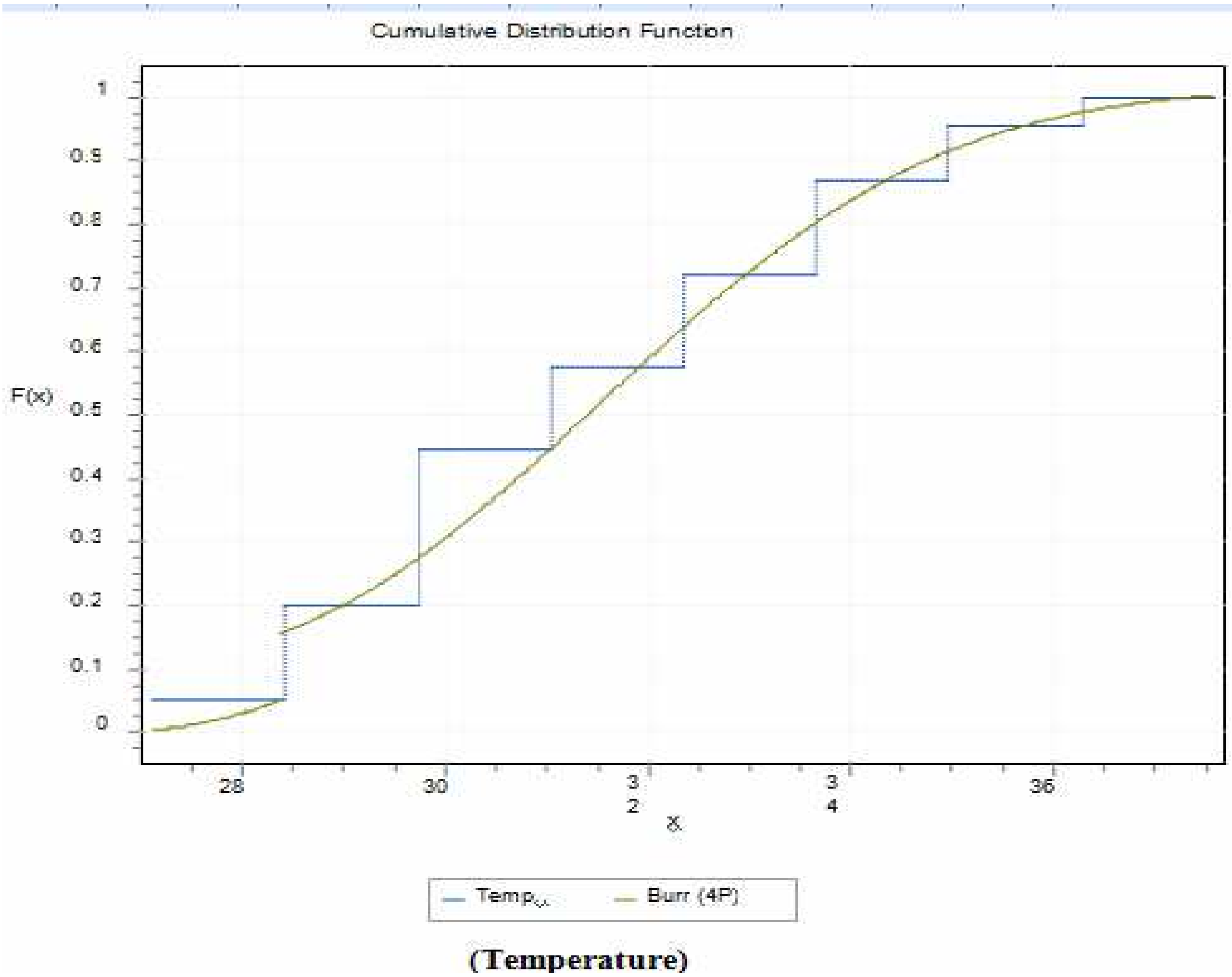

Figure 2: Cumulative Distribution Graph for the Burr Density (Temperature)

Table 2: Estimates of the parameters of the Modified Burr Density Function

Rainfall		**Temperature**	
p	1.7027	p	2.531
c	659.43	c	44.719
γ	-4.5678	γ	26.416
v	13.679	v	147.07

Table 3: Descriptive Statistics from the Data and Modified Burr Density Function

Data			**Burr Density**		
Descriptive Statistics	Rainfall	Temperature	Descriptive Statistics	Rainfall	Temperature
mean	133.00	32.00	mean	133.00	32.00
standard deviation	86.00	2.37	standard deviation	88.00	2.40
coefficient of variation	0.60	0.07	coefficient of variation	0.70	0.07
skewness	0.40	0.20	skewness	1.10	0.40

5.0 Conclusion

The suitability of the modified burr generalized density function in modeling the rainfall and temperature data of Ibadan, Oyo State, Nigeria has been established. The estimates of the descriptive statistics from the original rainfall and temperature series compare well with the ones obtained from the fitted burr density. The finding of the study is in line with [18] who noted that it can be used to model several skewed life datasets. The burr density has shown its susceptibility to further mathematical treatments for the purpose of easy parameter estimation. The density function is therefore recommended for future skewed datasets where finding an appropriate density function is of primary concern.

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References

[1]. Soneye, A. (2012) Population and Climate Change: NIGERIA Case study A draft report prepared towards the 2012 Pan African Session for LEAD Africa, in Malawi, November, 2012

[2]. Emaziye, P. O., R. N. Okoh and P. C. Ike (2012): “A Critical Analysis of Climate Change

Factors and its Projected Future Values in Delta State, Nigeria", *Asian Journal of Agriculture and Rural Development, Vol. 2, No. 2, pp. 206-212*

[3]. Zuviria, M. and Canziani, O.F. (2003) 'Spatial Modelling of Climatic Parameter Fluctuation Mapping Temperature Variation in the Barmejo Basin from 1901 to 2000' http://goo.gl/DoxqrJ. Accessed 14-08-2013

[4]. Olusina, J.O. and Odumade, O.M. (2012) 'Modelling Climatic Variation Parameters of Nigeria Using The Statistical Downscaling Approach', Knowing to manage the territory, protect the environment, evaluate the cultural heritage, Rome, Italy, 6-10 May 2012. FIG Working Week 2012 TS07F - Task Force on Surveyors and the Climate Change II, 6099,1-17

[5]. Ehigiator, O.A. (2013) 'Rainfall Trends in a Tropical Watershed in South- Western Nigeria', *1:574 doi:10.4172/scientificreports.574*

[6]. Kurukulasuriya, P and Mendelsohn, R, (2006) 'A Ricardian Analysis of the Impact of Climate Change on African Cropland', CEEPA Discussion Paper No.8. Centre for Environmental Economics and Policy in Africa, University of Pretoria

[7]. Lobell, D. B. and Burke M. B. (2008) 'Why are agricultural impacts of climate change so uncertain? The importance of temperature relative to precipitation', *Environ. Res. Lett.* **3** 034007

[8]. Adams, R.M., Glyer, J.D., McCarl, B.A., Dudek, D.J. (1988) 'The implications of global change for western agriculture', *West J Agric Econ 13:348–356*

[9]. Deressa, T., Hassen, R., Alemu, T., Yesuf, M., and Ringler, C. (2008) 'Analyzing the Determinants of Farmers' Choice of Adaptation Measures and Perceptions of Climate Change in the Nile Basin of Ethiopia. International Food Policy Research Institute (IFPRI) Discussion Paper No. 00798. Available online at http://link.springer.com/article/10.1007/s10640-011-9538-y