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Analysis of the Impacts of Climate Change in N'Zerekore

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Abstract
For several years now, West Africa has been experiencing very high levels of climate variability. At first glance, climatology is concerned with the mean values of meteorological parameters, their dispersion around this mean, extreme values and their return periods. The calculation of means is therefore the basis of climatic analysis. The calculation of averages is therefore the basis of climatic analysis. The variability of meteorological parameters is research that consists of analysing and synthesising data that mainly concerns the atmosphere of a place and whose complex action influences the existence of the beings that are subject to it. The meteorological data used in this study, i.e. rainfall, humidity and temperature (minimum and maximum) from the N'Zerekore Synoptic Station.
Keywords: Interannual variability, number of rainy days, cumulative rainfall, climate analysis.

Introduction
All national climatological activities, including research and applications, are based primarily on observations of the state of the atmosphere or the weather. 2017 was the third hottest year on record over the African landmass since 1950, after 2010 and 2016 (ACMAD, 2017). Analysing the impact of climate change in N'Zerekore is research that consists of analysing and synthesising data mainly from the atmosphere of a place whose complex action influences the existence of the beings subject to it. The meteorological data used in this study, namely rainfall, humidity and temperatures (minimum and maximum) from 1991 to 2020, were extracted from the National Directorate's well-preserved archives.

The analysing of the impacts of climate change aims to study trends that quantify rainfall over time. Trends can be observed over time. Here, with 30 years of data, the series are long enough to identify changes in temperature and rainfall. For the climate diagnosis, it is mainly changes in rainfall that will be studied.

However, we need to distinguish between climate variability, which is a natural and normal phenomenon, and climate change linked to anthropogenic phenomena, which is a sustained and irreversible modification of the climate. Worldwide, these changes have been observed since 1990, with significant warming of between 0.4 and 0.8 degrees.

Methods, Techniques, Studied Material and Area Descriptions
Studied Material Area Description
N'Zérékoré is one of the six (6) Prefectures of Forest Guinea. It lies between 07°32 and 08°22 latitude North and 9°04 longitude West and covers an area of 47.3 km^2.

It is bordered to the east by the Prefecture of Lola, to the west by the Prefecture of Macenta, to the south by the Prefecture of Yomou and the Republic of Liberia, and to the north by the Prefecture of Beyla. N'zerekore covers an area of around 4,625 km^2 and has a population of 284,903, with a density of 62 inhabitants per km^2. It is made up of ten (10) sub-prefectures and one urban commune.

Source: (Les Merveilles de la Guinée Forestière)

Techniques

These data are available for the period 1991-2020 at the N'Zerekore synoptic station in the network of Guinea's National Direction of Meteorology. This period will constitute our temporal base for the study and will enable us to better appreciate rainfall variability, relative humidity and temperatures.

Table 1: Characteristics of synoptic stations

Stations	Code OMM	Latitude (North)	Longitude (East)	Altitude	Observation start date
Koundara	61812	12,34	-13,31	79	1970
Boké	61816	10,56	-14,19	69	1922
Conakry	61832	9,34	-13,37	26	1903
Kindia	61810	10,03	-12,52	458	1922
Mamou	61820	10,22	-12,05	782	1921
Labé	61809	11,19	-12,18	1029	1903
Faranah	61830	10,02	-10,03	340	1923
Siguiri	61811	11,26	-9,10	362	1922
Kankan	61829	10,23	-9,18	377	1922
Kissidougou	61830	9,11	-10,06	450	1903
Macenta	61847	8,32	-9,28	543	543
N'Zérékoré	61849	7,45	-8,47	395	1922

Methods

The methodological approach is based on records of climatic data observed at the N'Zérékoré synoptic station; meteorological data for the period 1989-2018 were used as the basis for this study, which covers rainfall, humidity and temperature, which are published in the form of climatological bulletins (monthly, seasonal and annual). Monthly climatological tables (TCM) are also drawn up to summarise the physical state of the environment during the month.

The treatment products are: The average of the daily values recorded during the month (mean values); the highest or lowest value recorded during the month (extreme values); the sum of the daily values recorded during the month (cumulative values); the number of days above or below a given threshold, or during which a phenomenon occurs.

N'Zerekore's climate is characterised by two alternating seasons: a dry season and a wet season. This alternation is caused by inter-tropical convergence zone. The data collected was processed using advanced Excel software, to aggregate certain monthly data into annual data, for statistical processing and presentation of the results. The gentleness or rigour of this study is confirmed by the variation in the observed parameters calculated in relation to the average over the period under consideration. This study analyses these variations and interprets the results.

Results

Interannual variation in rainfall in N'zerekore

Rainfall patterns in West Africa have varied considerably over time. After the relatively wet 1950, it has seen a sharp drop in rainfall in recent decades [f, g - h]. However, since the mid-1990s there has been an attempt to return to better rainfall conditions in several areas, albeit with increased inter-annual variability characterised by a sudden alternation of wet and dry years. Averaging is used to describe the climate and to make spatial and temporal comparisons.

The Technical Regulations of the World Meteorological Organisation (WMO) contain the following definitions:
Period average: the climatological data calculated for any period of at least ten years beginning on 1st January of a year.
Reference period average: avere calculated over the longest period.
Climate normal: average value 30 years and used as a reference to characterise the climate.
The rainy season lasts 8 months, beginning in May and ending in October. Annual rainfall varies between 1506.6 mm in 2006 and 2314.7 mm in 2010, with an average of 1899.49 mm. The following periods can be deduced from the moving average (***see Figure 1***).

- One surplus period: 2010 - 2017
- Two periods of deficit: 1990 - 1993 and 2001 - 2009
- One period close to normal: 1994 – 2004

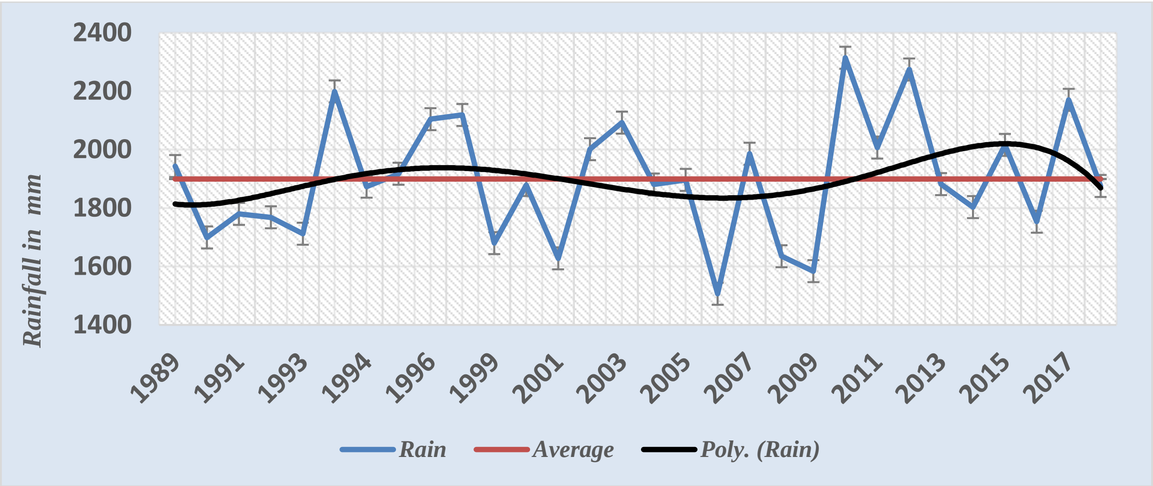

Figure 1: Interannual variation in rainfall in N'Zerekore from 1989 to 2018

Annual rainfall monitoring in N'Zerekore shows an upward trend in average cumulative rainfall per year. The linear regression line (red dotted line) shows that it has risen from around 1943 mm in 1989 to over 2170 mm in 2017. Cumulative rainfall trends are initially marked by inter-annual variability. The increase observed is mainly due to increasingly high maximum annual totals, with minimum totals remaining between 1,500 and 1,700 mm (***see Figure 2***).

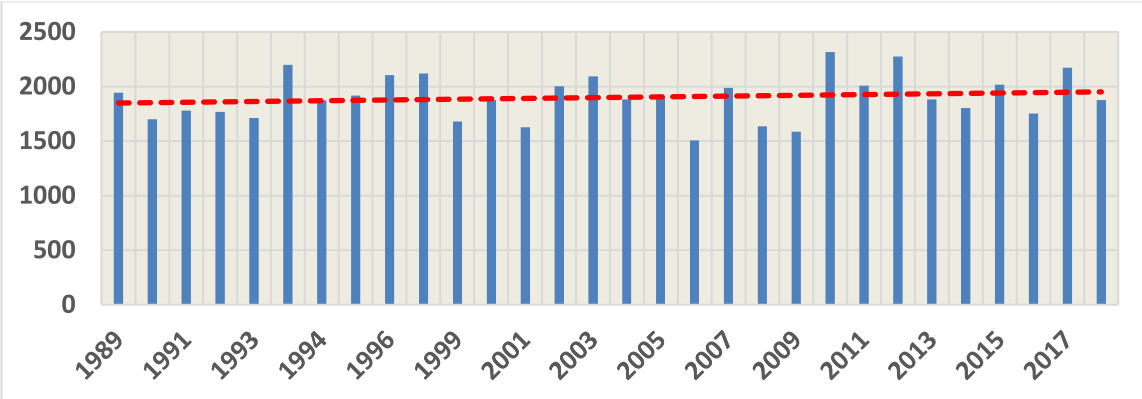

Figure 2: Cumulative rainfall by year in N'Zerekore form 1989 to 2018

Monthly total:
N'Zerekore is characterised by two alternating seasons, a dry season a rainy season lasting 8 months; wettest months are: June, July, August and September with an average 1090.61 mm respectively (***Figure 3***).

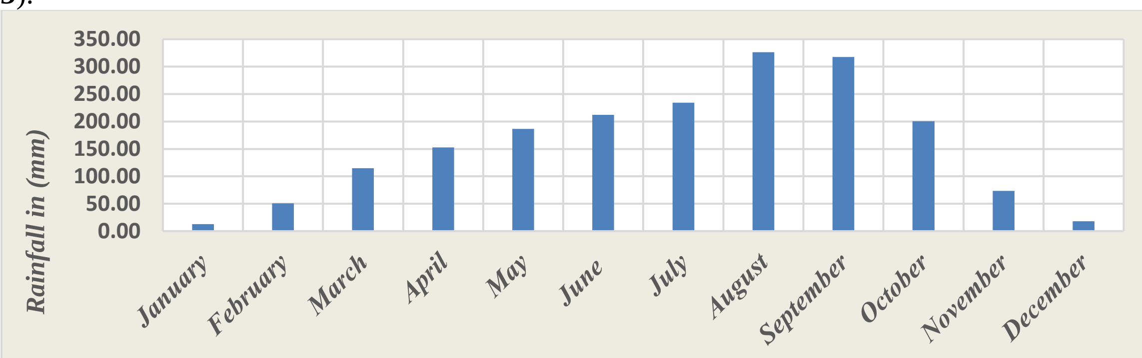

Figure 3: Monthly variation in rainfall in N'Zerekore from 1989 to 2018

Figure 4 shows the histogram of annual rainfall distribution and the annual curve in N'Zerekore. Rainy are those on which the cumulative rainfall is greater than or equal to 1 mm. Below this threshold, the uncertainties are too great to know whether it has rained.

The analysis of the number of rainy days will give an idea of the frequency and distribution of precipitation by seasonality of precipitation and their distribution over the year, season or month give an indication of the distribution of rainfall.

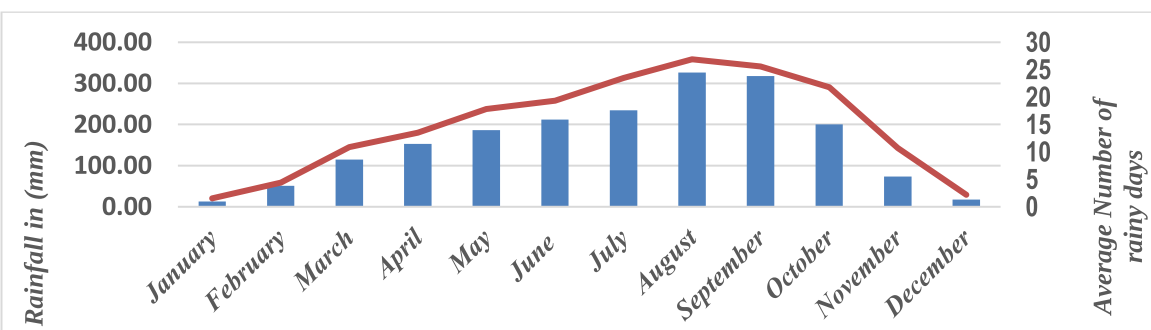

***Figure 4: Annual distribution curve of the number of rainy days in N'Zerekore*.**

Table 2: Monthly rainfall statistics (1989-2018)

Months	Precipitation				Rainy days			
	Average	**Maximum**	**Minimum**	**Deviation**	**Averafe**	**Maximum**	**Minimum**	**Deviation**
January	13,06	74,6	0	20,6	2	6	0	1,9
February	50,59	133,8	0	35,6	4	11	0	3,1
March	114,84	262,2	25,7	60,9	11	16	5	3,0
April	152 ,75	270,05	52,3	57,9	14	18	9	2, 3
May	186,30	329,1	107,2	67,5	18	24	11	3,0
June	212,01	350,9	107,2	81,4	19	23	13	2,8
July	234,40	404,4	89,3	84,1	24	29	17	3,5
August	326,25	539,6	185,5	78,6	27	31	21	2,2
September	317,72	517,6	135	80,5	26	29	21	2,1
October	200,24	452,4	135	39,5	22	28	12	3,5
November	73,51	162,5	4,9	24,6	11	18	4	3,8
December	17,83	82,3	0	206,3	2	7	0	1,9
Total	**1899,49**	**2315**	**1507**	**-**	**15**	**31**	**0**	**-**

Daily:

A climate analysis of N'Zerekore requires a detailed analysis of rainfall. For a climatic analysis, daily data are the most suitable, and provide a good level of precision in the climatic analysis. While hourly data is too accurate for long-term climate analysis, monthly totals mask a wide disparity in rainfall on a daily scale and are therefore not relevant for climate analysis. The absolute daily maximum observed was 125.2 mm recorded on 17/09/2017.

Daily rainfall is generally highly variable. To illustrate this highly variable daily rainfall in N'Zerekore, example diagrams (Figures 5a, 5b and 5c) of annual daily rainfall records are shown for the wettest year (2010), the driest year (2006) and a normal year (2005). From these diagrams, we can see that there is a clear difference between these years. In 2006 (see **Figure 5b**), a dry year, the rainy season began on 8 February and ended on 8 November with 2 daily rainfalls in excess of 50 mm. By contrast, in 2010 (see Figure 5a), a very wet year, the season began on 01 January and ended on 25 December with 5 daily rainfalls in excess of 50 mm. In 2005 (see Figure 5c), a normal rainy year, the season began on 30 January and ended on 25 December. Although it was a normal year, 4 daily rainfalls in excess of 50 mm were recorded. So wet and dry years differ not only in terms of the quantity, length and distribution of rainfall during the season.

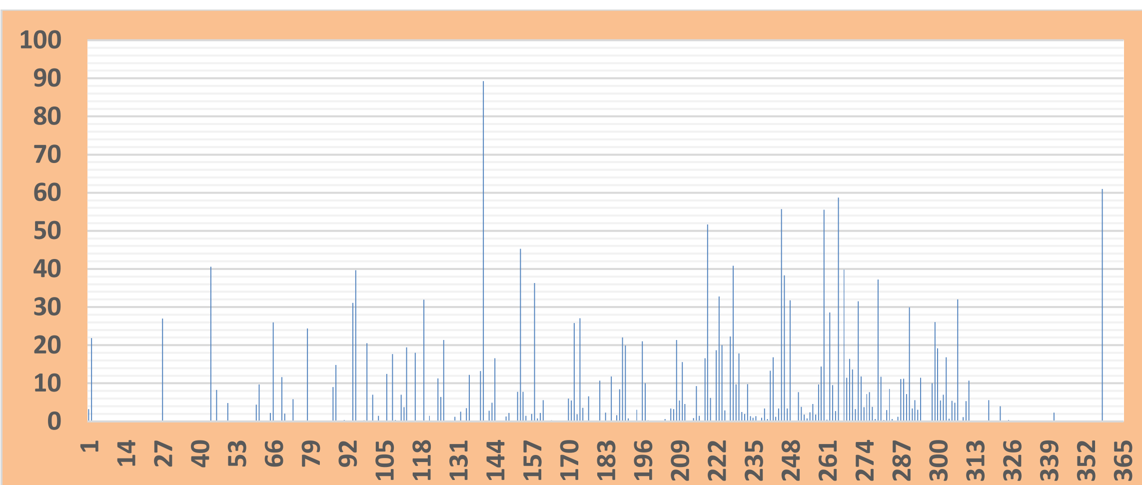

Figure 5b: Daily rainfall totals for N'Zerekore in 2006.

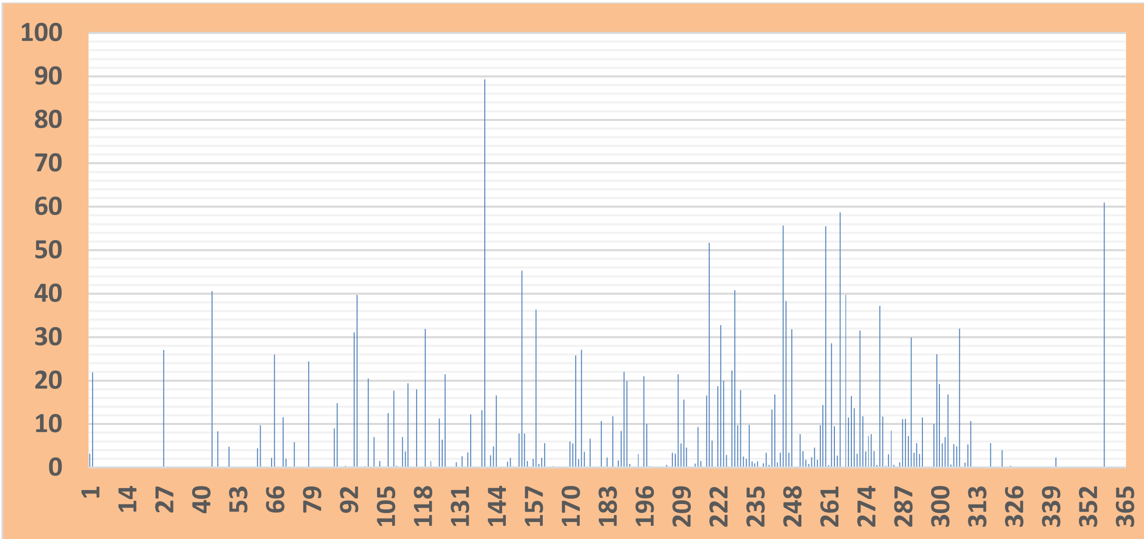

Figure 5a: Daily rainfall totals for N'zerekore in 2010.

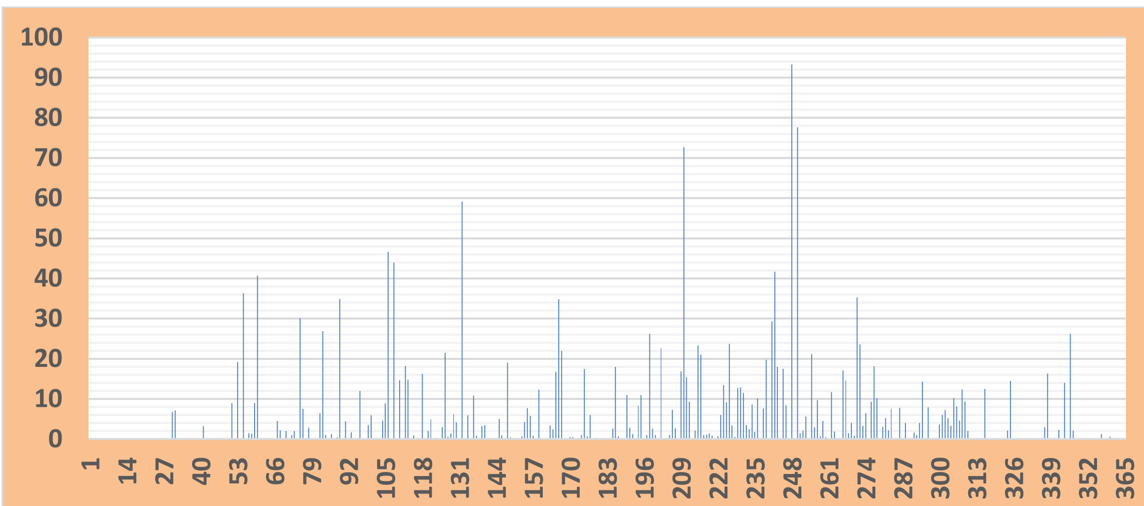

Figure 5a : Daily rainfall totals for N'zerekore in 2005.

Temperature

For some time now, extreme climate variations have manifested themselves in a drastic increase in temperature and a scarcity of rain due to mining, the use of chemical products and excessive logging... and the socio-economic consequences have had a lasting impact on communities.

Temperature is the result of various heat exchanges in the environment. The temperature of an environment is essentially a manifestation of solar radiation and the energy balance. Temperatures in N'Zerekore are softened by the action of the vegetation and vary very little. The average temperature is 25.4°C. Extreme values of 38°c were observed on 29/02/1998 and 9.5°c on 01/01/ 1989 for the minimum temperature.

Figure 4 the variation curves for maximum and minimum temperatures in N'Zerekore. Maximum temperatures 31.9°C and 33.2°C, while minimum temperatures ranged 17.2°C and 21.6°C.

Tableau 2: Monthly temperature distribution N'Zerekore period (1989 – 2018)

Mois	January	February	March	April	May	june	July	August	September	October	November	December	Average
T min (°C)	17,2	19,5	21,2	21,6	21,6	21,3	20,9	20,9	21,0	20,6	20,4	18,3	20,4

T maxi (°C)	31,9	33,2	32,5	31,4	30,6	29,3	27,7	27,8	29,0	29,8	30,4	30,9	30,4
T average(°C)	24,5	26,3	26,8	26,5	26,1	25,3	24,3	24,3	25,0	25,2	25,4	24,6	25,4

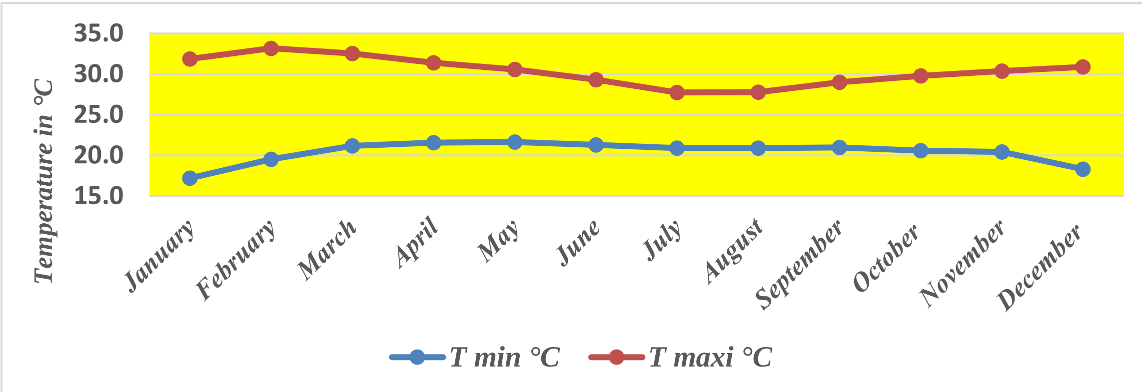

Figure 7: Variation in mean maximum and minimum temperature in N'Zérékoré, 1989-2018

Relative humidity
Relative humidity in N'Zerekore is highly variable. It can reach 90% during the rainy period (April to October) in the early morning or during heavy rains. On the other hand, during the harmattan period (January to March), relative humidity is low. It can fall below 70% in the afternoons. Average relative humidity fluctuates between 65 and 90%.

Table 4: Monthly distribution of relative humidity in N'zerekore for the period (1989 - 2018)

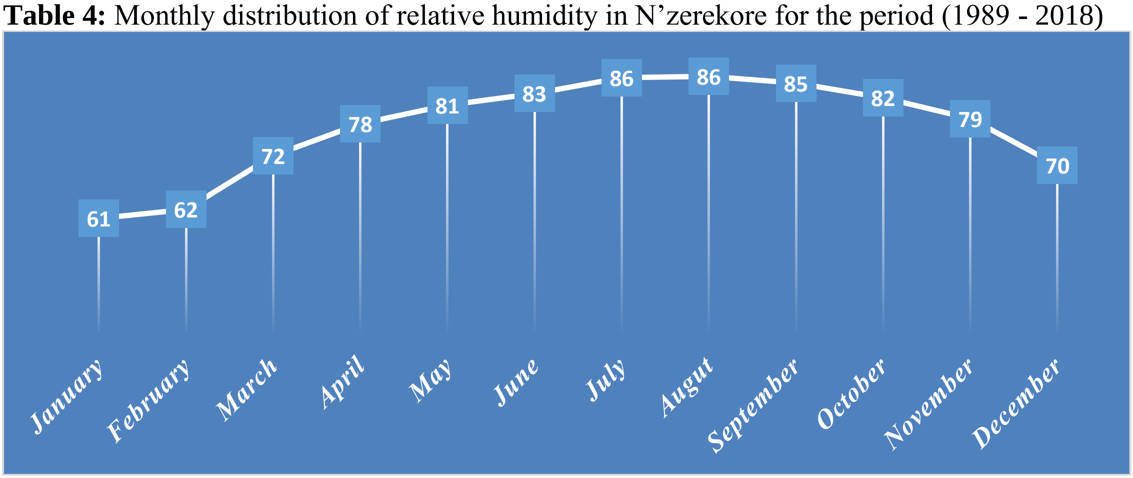

Figure 8: Monthly variation in average humidity in N'Zerekore, 1989-2018

Climatic elements such as temperature, humidity, wind, radiation and evapotranspiration have a certain influence on plants. Data on temperature thresholds and humidity will guide the choice of the best techniques for preserving agricultural produce. Depending on rainfall data (quantity, distribution, length of season) and temperatures (maximum, minimum, average, variation) in N'Zerekore, all cereal crops (rice, fonio, maize, millet) are suitable, and vegetable crops (potatoes, cabbage, carrots, beans, tomatoes, chillies, etc.) can be grown several times a year.

Conclusion
Many diseases are directly or indirectly associated with climate. Vector-borne diseases such as malaria are sensitive to changes in meteorological parameters such as rainfall, temperature, wind and humidity. Malaria and other vector-borne diseases generally occur in regions with high temperatures (18°C to 32°C) combined

with relative humidities (>60%), monthly rainfall exceeding 80mm (Hellmuth et al. 2007) and high vegetation cover. These climatic and environmental parameters create favourable conditions for the survival and development of the vector mosquitoes responsible for malaria.

By analysing the variation curves for temperature, rainfall and humidity, we can see that the climate conditions for survival of the mosquito responsible for malaria transmission are met March-October and November-February respectively. Knowing this climatic information will enable health services to plan ahead and raise awareness in order to reduce the risk of epidemics.

According to B. Givoni, comfort conditions are linked to temperature and humidity. And the comfort zone is delimited by temperatures of 20 and 27°C and relative humidity of 20 and 80%. According to the analysis of the temperature and humidity curves, N'Zérékoré is in the comfortable zone during the day, with the exception of the periods from January to February because of the high temperatures and from July to September because of the high humidity. On the other hand, nights are uncomfortable and require heating.

For the recommendations: Particularly in December-January due to the drop in temperature caused by the harmattan, and from July to September due to high humidity and the drop in temperature caused by heavy rain and low sunshine. The meteorological data used in this study, i.e. rainfall, humidity and temperature (minimum and maximum) from the N'Zerekore Synoptic Station the 1991 - 2020, were extracted from the well-preserved archives of the National Directorate. The climatic data collected underwent statistical processing and analysis, including: trend development over the study period; inter-annual variation, cumulative annual rainfall and cumulative monthly rainfall, number of rainy days, variation in mean maximum and minimum temperature and monthly variation in mean humidity. The analysis of these variations and the interpretation of the results are the subject of this work.

Acknowledgements

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