ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25jun955

Rainfall Variability and Flood in Epéna (Congo-Brazzaville)

[1]Gaston Samba

[1]Center for Environmental Research and Studies, Marien Ngouabi University, Brazzaville, Republic of Congo

Publication Date: 2025/07/21

Abstract: The urban community of Epéna, in northern Congo, has been at risk of recurrent flooding for several decades. To this end, the present study aims to analyze rainfall variability from 1980 to 2022 in Epéna and its impact on the rate of flooding observed between October and November 2022. To carry out this study, we used data from the ERA5 reanalyses, consisting essentially of daily rainfall data over the period from January 01, 1980 to December 31, 2022. To this we added sequences of field images. These data were processed according to a methodological protocol based on descriptive statistics and the Pettitt test. The results obtained show that precipitation shows slight fluctuations at monthly and annual, but is highly irregular at seasonal level. The Pettitt test shows a period of change in the distribution of annual precipitation at Epéna between 1908 and 2022. These results also showed that the daily rainfall totals recorded between October and November 2022 at Epéna) were responsible for the floods observed on October 20, 2022 and on November 02 and 29, 2022 Levels.

Keywords: *Rainfall , Variability Occurrence, Flooding, Epéna, Northern Congo.*

How to Cite: Gaston Samba (2025). Rainfall Variability and Flood in Epéna (Congo-Brazzaville). *International Journal of Innovative Science and Research Technology,* 10(6), 3283-3292. https://doi.org/10.38124/ijisrt/25jun955

I. INTRODUCTION

This study takes place in a national and international context marked by climate change. The town of Epéna is located in the Likouala department (in the northern part of the Congolese territory), between longitudes 17°26'31" and 17°27'49" E and latitudes 1°21' and 1°21'50" N (fig. 1). This town is part of the western margins of the Congo Basin, which for several decades has been experiencing the effects of climate change [1] [2] [3] [4] [5]. These effects are manifested through phenomena such as recurrent flooding, temperature rises in urban areas and irregularities in the seasonal rainfall cycle. In the intertropical zone, rainfall is one of the key climatic parameters for detecting signals of climate change [6]. In this part of the country, daily rainfall is often responsible for enormous material and human losses, as well as for the displacement of forced people. However, analysis of daily rainfall shows that rainfall in northern Congo is fairly high. On a rainy day, between 20 and 30 mm water can be recorded [6]. However, the resurgence of flooding phenomena in this region has prompted us to question the recent rate of these phenomena in the urban community Epéna. To this end, this study aims analyze rainfall from variability 1980 to 2022 and its impact on the rate of flooding observed in Epéna between October and November 2022. The aim is to contribute to the rational planning of various human activities (forestry, agriculture and land use) in a context where the preservation of ecosystems (human and natural) remains a major challenge for the country's leaders.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25jun955

Fig 1 Satellite Image (January 22, 2023) of the Town Epéna with ERA5
(Source measuring point: Google Earth, image CNES/Airbus 2023).

II. METHODOLOGICAL

➢ *Data*

For this study, we used data from ERA5 reanalyses with a spatial resolution of 0.25°x 0.25°. The extracted files mainly concern daily precipitation data from January 01, 1980 to December 31, 2022 for the town of Epéna. Simulation and satellite data are increasingly used in current and future climate analyses. They have fewer shortcomings, as they take into account all the parameters governing a region's climate system. Added to this are sequences of field images illustrating the occurrences of flooding observed in the town of Epéna between October and November 2022.

➢ *Methods*

We used various methods and a statistical test to process the precipitation data. All data processing was carried out using Xlstat 2014 and Excel 2016. The various methods used are as follows:

Cumulation, which is the sum of the values contained in a series or matrix. This method enabled us to identify the occurrences of flooding in Epéna during the period October-November 2022. It is defined as follows:

$$\sum \mathbf{X}i$$

Where:

Xi as the series variable (here, xi = precipitation).

The simple arithmetic mean, which is the ratio of the sum of the values in the statistical series to the number of values. It has enabled us to represent the rainfall regime and the averaged values of precipitation occurring during each season. This method is defined as follows:

$$\overline{X} = \frac{1}{N}\sum_{i=0}^{n} \mathbf{X}i$$

Where:

Xi, series variable; n, number of variables; N, total number of variables.

The coefficient of variation, which is the ratio of the standard deviation to the mean, multiplied by 100 to give a percentage result (%). This coefficient enables us to measure the homogeneity (or variation) of the data in the rainfall series. It is given by the following formula :

$$\frac{\sigma}{\overline{X}} \text{ x } 100$$

Reduced centered anomalies were used to assess precipitation trends through rainfall indices. This method is defined as follows:

$$\mathbf{RCA} = \frac{(\mathbf{X}i - \overline{X})}{\sigma}$$

Where:

- *RCA:*

Reduced Centered Anomalies; *Xi*: *series variable;* σ: *standard deviation*; $\overline{X}$: average.

The statistical test used for this study is essentially the Pettitt test used under Xlstat 2014 software.

The Pettitt test The Pettitt test was used to identify any breaks in the precipitation time series. This is a non-parametric test (requiring few assumptions) that identifies the time at which a change occurs. Its implementation assumes that for any time t between 1 and N, the time series *(Xi) i=1 to t and t+1* to N belong to the same population. The variable

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25jun955

to be tested is the maximum absolute value of the variable *Ut, N* defined by:

$$U_{t,N} = \sum_{i=1}^{t} \sum_{J=t+1}^{N} Dij$$

Where :

Dij = sgn(Xi –Xj) et sachant que :

sgn(X) = 1 si X>0 ;

sgn(X) = 0 si X = 0 ;

sgn(X) = -1 si X <0.

The analysis of the urban heat island (UHI) in the city of Brazzaville was based on in-situ temperature data from thirty thermometers placed at different measurement sites. This makes it possible to go down to fine scales and includes urban physics modules. Averages were calculated for each site and at different times of day. Values were taken at 6 o'clock in the morning, 12-13 o'clock at noon and 18 o'clock in the evening. The method used to identify UHI in this study is based on an empirical approach. The originality of the methodological approach proposed in this article lies in the cross-referencing of parameters that show a strong correlation with the UHI phenomenon, leading to the obtaining of precise results. In particular, in situ observations are favored given the scarcity of documentation on the urban heat island in a humid tropical city in a developing country. Subsequently, the use of geomatics software and even GIS in the relatively new field of UHI cannot be ruled out.

III. RESULTS AND DISCUSSION

➢ *Rainfall Variability*

- *Rainfall Regime*

Fig. 2 shows that rainfall in Epéna has a bimodal (typical pattern of equatorial) climates, with alternating dry and wet. The first dry period runs from December to February. This period forms the DJF season, with monthly rainfall barely reaching 100 mm. This is followed by the first wet period, represented by the months of March, April and May (forming the periods March-April-May (MAM)). During this first wet period, rainfall values in excess of 150 mm are recorded. The second dry period occurs between June and August, forming the JJA season. Here, monthly can exceed 100 mm. The second wet period begins in September to November.

This is the SON season, with the highest monthly rainfall (over 160 mm).

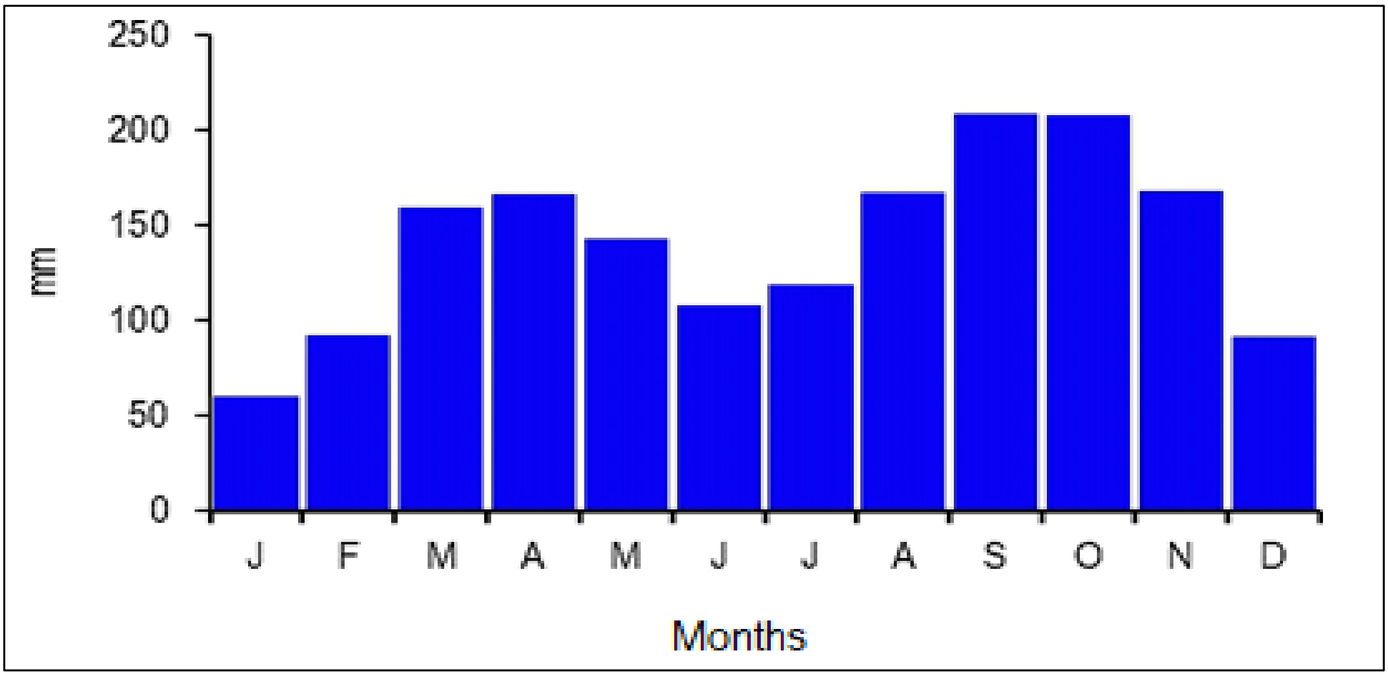

Fig 2 Rainfall Pattern at Epéna.

- *Monthly Precipitation*

The monthly precipitation pattern at Epéna from 1980 to 2022 reveals a mosaic dominated by high irregularity (with a coefficient of variation of 31%). Analysis of ERA5 simulation data (Fig. 3) shows a stable monthly precipitation cycle over the period from 1980 to 1990. However, from the 2000s onwards, there are significant discontinuities in the distribution of monthly precipitation. This will continue until 2022. September, October and November have always been the wettest months, with rainfall totals of up to 294 mm. However, from the 2000s onwards, there has been a marked irregularity in the monthly rainfall cycle. Rainfall values rarely exceed 250 mm/month. The monthly cycle in March, April and May is not excluded from these irregularities. However, December, January and February remain the least rainy months, with rainfall totals of less than 80 mm/month.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25jun955

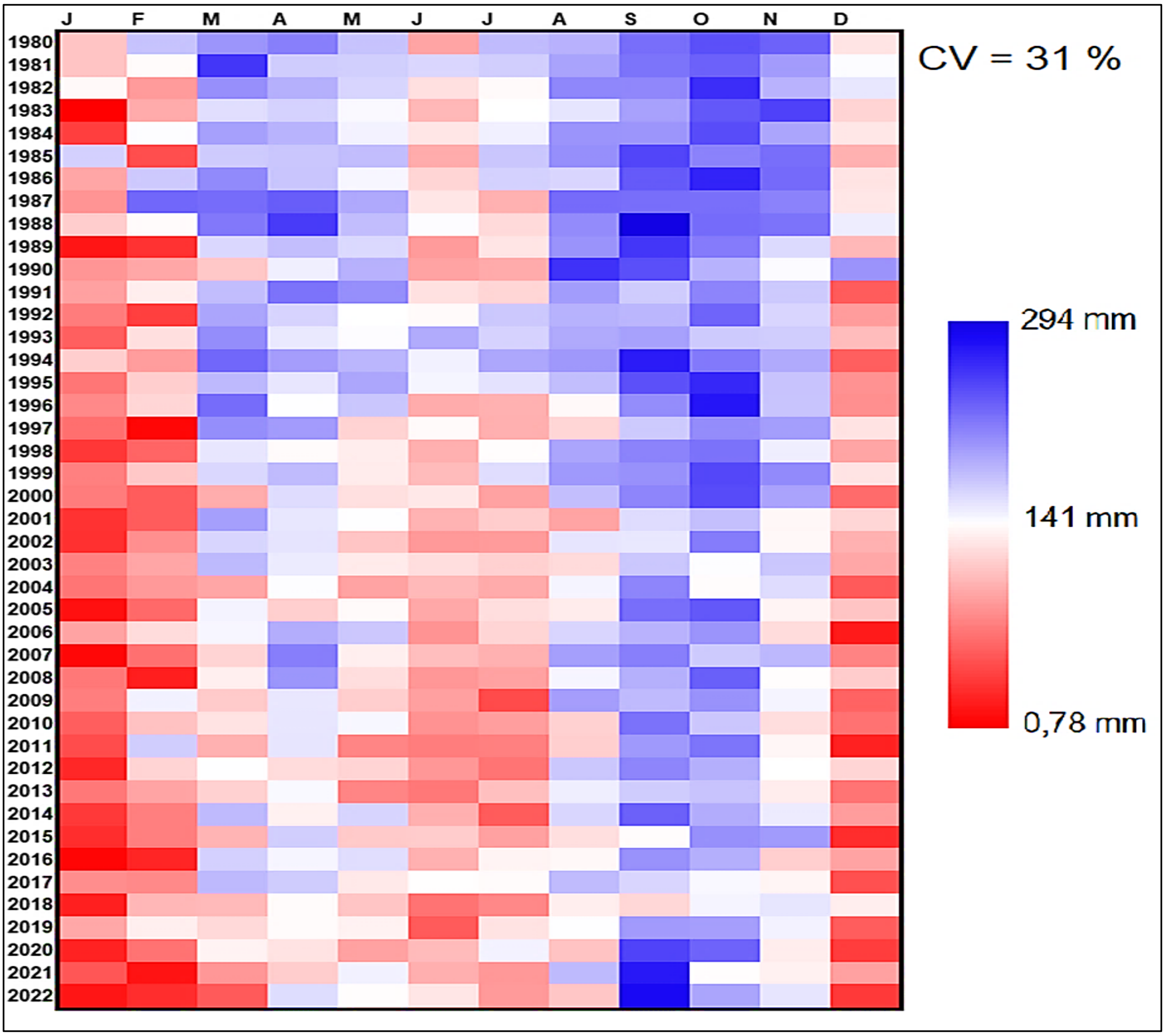

Fig 3 Monthly at Rainfall Patterns Epéna between 1980 and 2022.

* *Seasonal Precipitation*

Figu. 4 shows the different seasonal rainfall fluctuations in Epéna between 1980 and 2022. The climatic division of the seasonal cycle in Epéna takes into account the rainfall pattern and follows that of the equatorial zone in general. The analysis therefore focuses on the DJF, MAM, JJA and SON seasons. The DJF season (December-January-February) is the least rainy, with rainfall ranging from 70 to 430 mm. The highest values were recorded in 1987, when 430 mm water. The lowest value was recorded in 2022. However, precipitation is highly variable during the DJF season, with a coefficient of variation of 35%. This is followed by the MAM rainy season (March-April-May). Rainfall values during this season range from 320 to 654 mm of water. The highest rainfall values in the MAM season were recorded in 1987-1988, when rainfall exceeded 650 mm. And the lowest rainfall were recorded in recent years (2004, 2011 and 2013). However, with a coefficient of values variation of less than 30% (18%), the MAM season shows little fluctuation between 1980 and 2022. However, during the less rainy JJA season, recorded rainfall fluctuates between 290 and 563 mm of water. This season saw high rainfall in 1993 and low rainfall in 2011. The rainfall recorded during this season shows little variation, with a coefficient of variation of 19%. Finally, over the period from 1980 to 2022, rainfall recorded during the SON season (September-October-November) varies between 432 and 753 mm of water. Here, the highest rainfall values were recorded during the 1980s, with a peak 1988. The lowest values were recorded in 2018. Rainfall during this season does not fluctuate greatly, as shown by the coefficient of variation (13%). Applying the coefficient of variation to seasonal precipitation shows that, overall, the seasonal cycle precipitation remains less variable at Epéna. However, the few fluctuations observed in seasonal precipitation are often linked to north-south oscillations of the ITCZ and dynamic surface conditions.

ISSN No:-2456-2165
https://doi.org/10.38124/ijisrt/25jun955

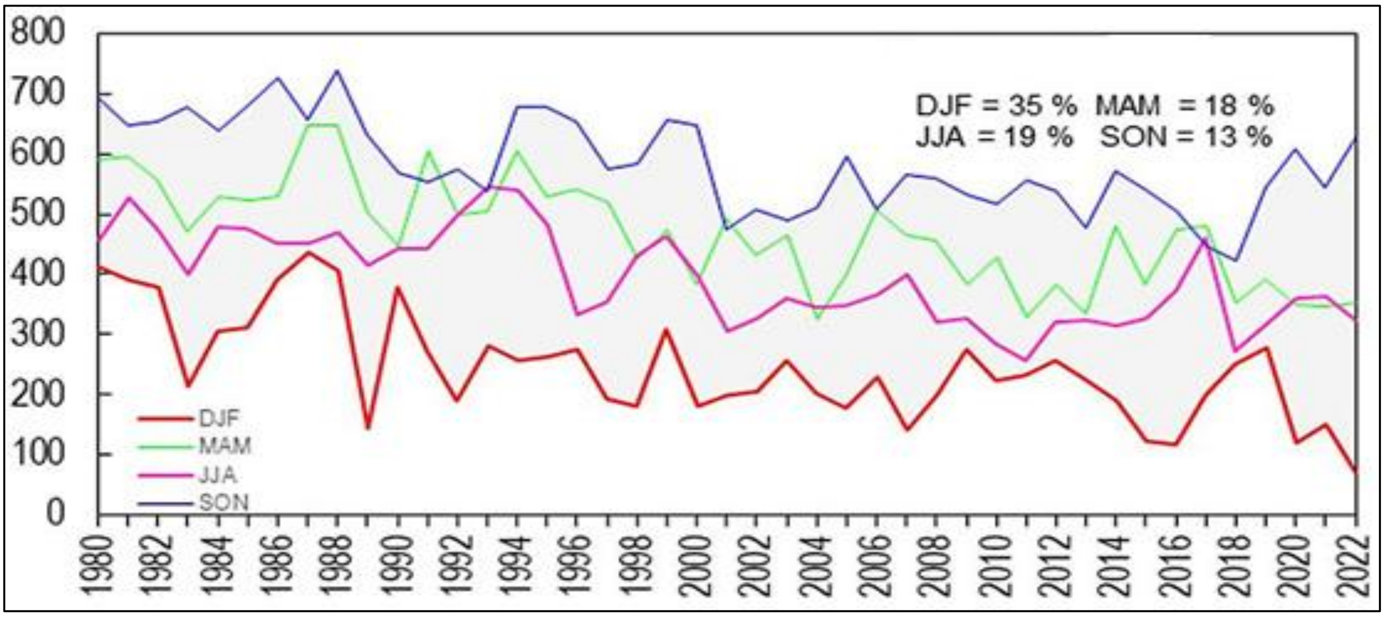

Fig 4 Seasonal Rainfall Variability at Epéna between 1980 and 2022.

- *Annual Precipitation*

Fig. 5 shows the variability of annual precipitation at Epéna from 1980 to 2022. Variations are fairly low, with a coefficient of variation of 16%. However, indices rainfall and the 2-year moving average point to a downward trend annual precipitation that began in the early 2000s. The ERA5 simulation data show 1988 as the wettest year (with 2265 mm of water) and 2018 as the year with the lowest rainfall totals (with 1298 mm water). These data, tested with Pettitt's break test (with 95%), attest to a break in the distribution of annual rainfall series at Epéna. The year 1999 marks the beginning of the break in the distribution of annual rainfall series. There is a considerable difference between the pre-break average (1934 mm) and the post-break average (1477 mm). Indeed, these analyses confidence level concur with the results obtained by [3] [1][7][8][5][10] predicting a significant drop in rainfall since the 1980s in the northern part of the Congolese territory**.**

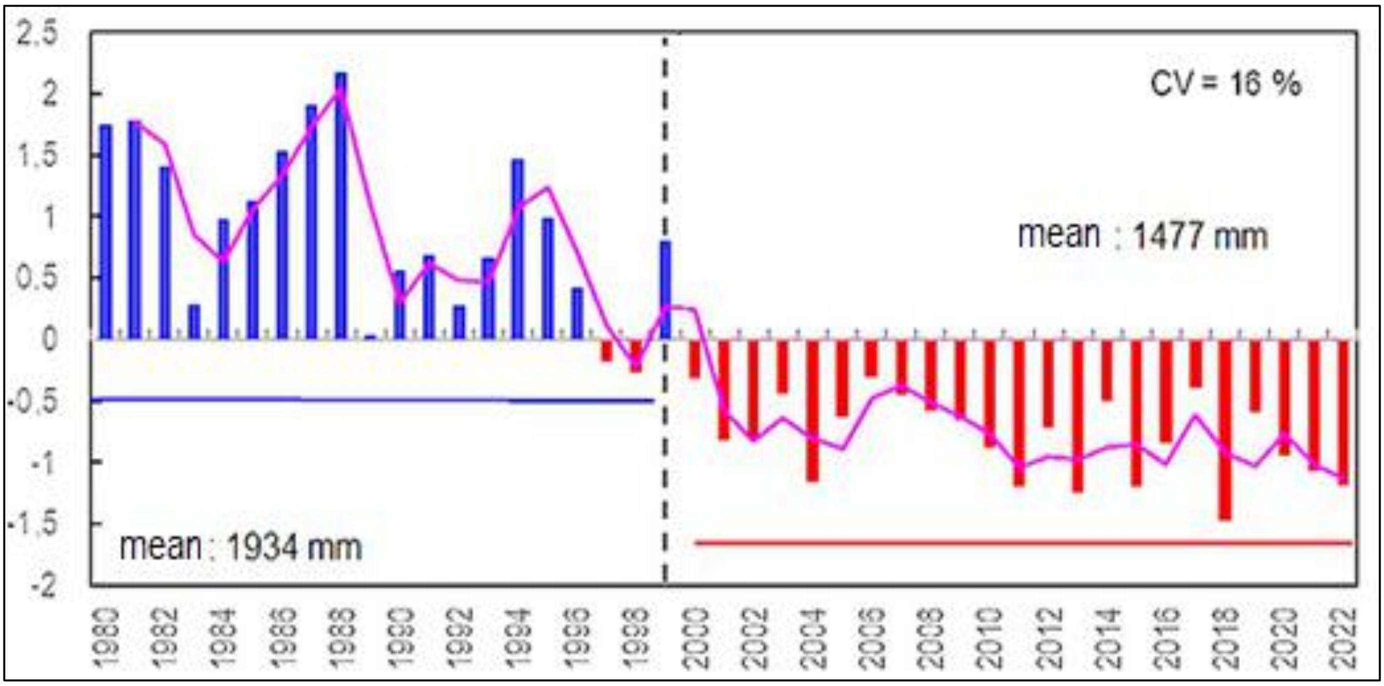

Fig 5 Variability and Break in Annual Precipitation at Epéna between 1980 and 2022.

➢ *Daily Rainfall Patterns and Flooding*

The modulation observed in daily rainfall is responsible for much of the frequent flooding in the Epéna. areaTo this must be added area (low 's low topographic levels altitudes of less than 325 mm). In order to shed light on recent flooding in the town of Epéna, we have selected the year 2022 for the analysis of daily rainfall and exceptional flood recorded in the same year. Occurrences.

➢ *Average Monthly Daily Precipitation Rate*

Over course of the2022, the monthly cycle of daily precipitation remains marked by values fluctuating between 0.4 and 9.11 mm water/day. Daily precipitation in excess of 5mm of water is often recorded in the following: months April, September, October and November (Fig. 6). The peak is in September, with an average of over 9 mm of water/day. This suggests that, on average, the month of September can record rainfall values of over 9 mm of water. The average rainfall in these results make these months (April, September, October and November) the months with the highest probability of flooding in Epéna. values.

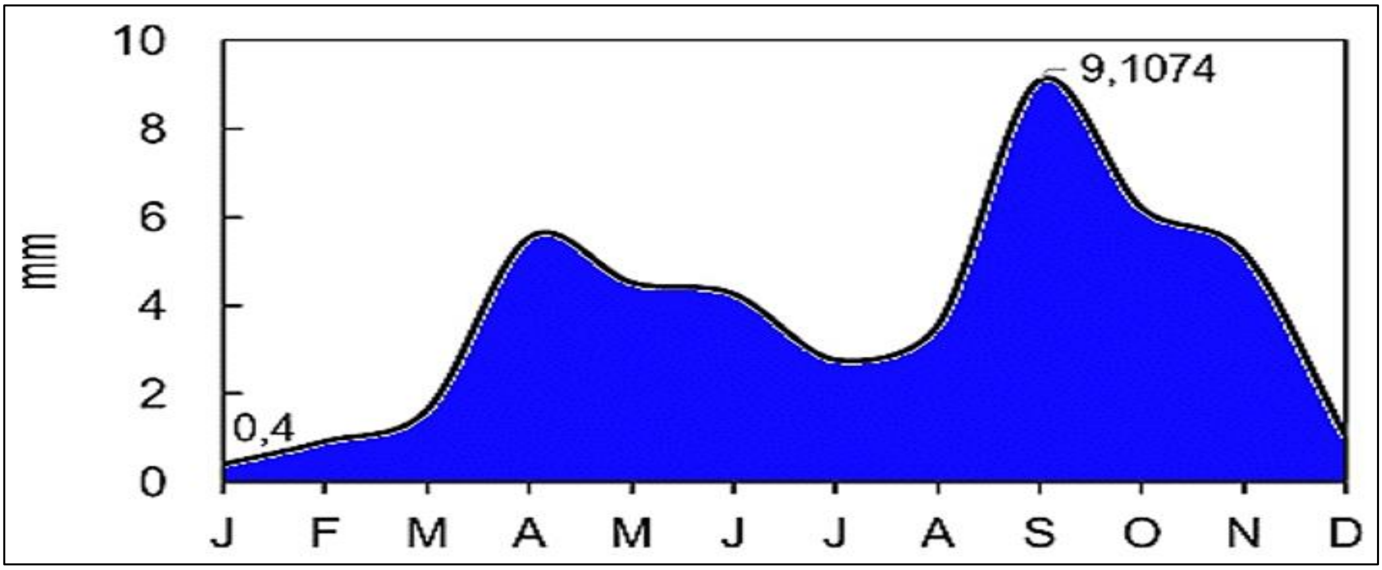

Fig 6 Average Monthly Daily Rainfall at Epéna between 1980 and 2022.

• *Average Annual Daily Precipitation Rate*

There are strong fluctuations (cv at 36%) in the distribution of mean annual values daily rainfall at Epéna (Figure 7). Over calendar year daily rainfall at Epéna is most frequent between days (for the first cycle) and days 21869th and 128th and 336th (for the second cycle). Daily rainfall during the second cycle of days is likely to bring waves of flooding to the town of Epéna.

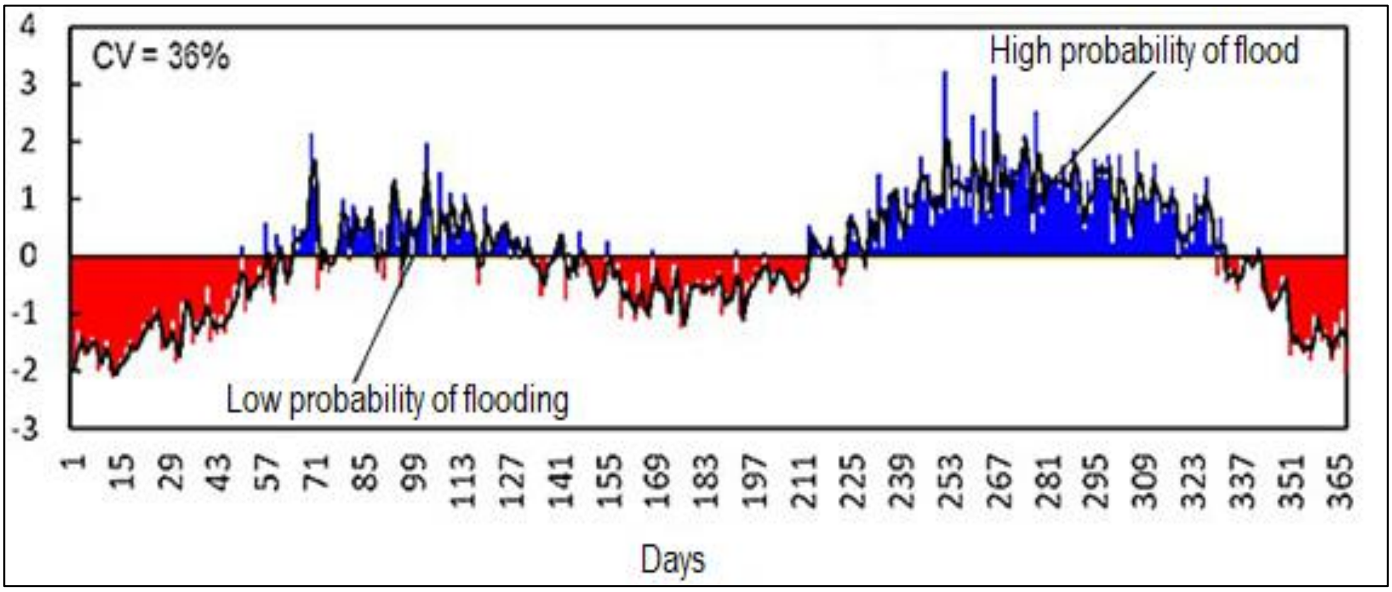

Fig 7 Average Annual Daily Rainfall at Epéna between 1980 and 2022.

This analysis makes it easier to identify the different phases that could potentially expose the town of Epéna to flooding. The ERA5 simulations approach a fairly logical reality when we take into account the dates on which flooding most often occurs in Epéna.

• *Occurrence Flooding in Epéna between October and November 2022*

Flooding in the Epéna area and its margins has increased with the current rate of climate change. In fact, over the period October-November 2022 we recorded, daily rainfall that can be considered as cumulative rainfall high (on

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25jun955

a local scale). These exceptional precipitation events are recorded when flooding occurs.

Over the period October-November 2022, ERA5 data identified daily rainfall totals in excess of 15 mm/day. Daytime rainfall in October ranged from 0 to 28.6183 mm (Figure 8a), with a peak on October 20, 2022. However, during the month of number, values ranging from 0.24 to 17.3045 mm water were recorded (figure 8b). High rainfall totals in November were recorded on November 02, 2022 (for 16.1913 mm of water) and November 29, 2022 (for 17.3045 mm of water).

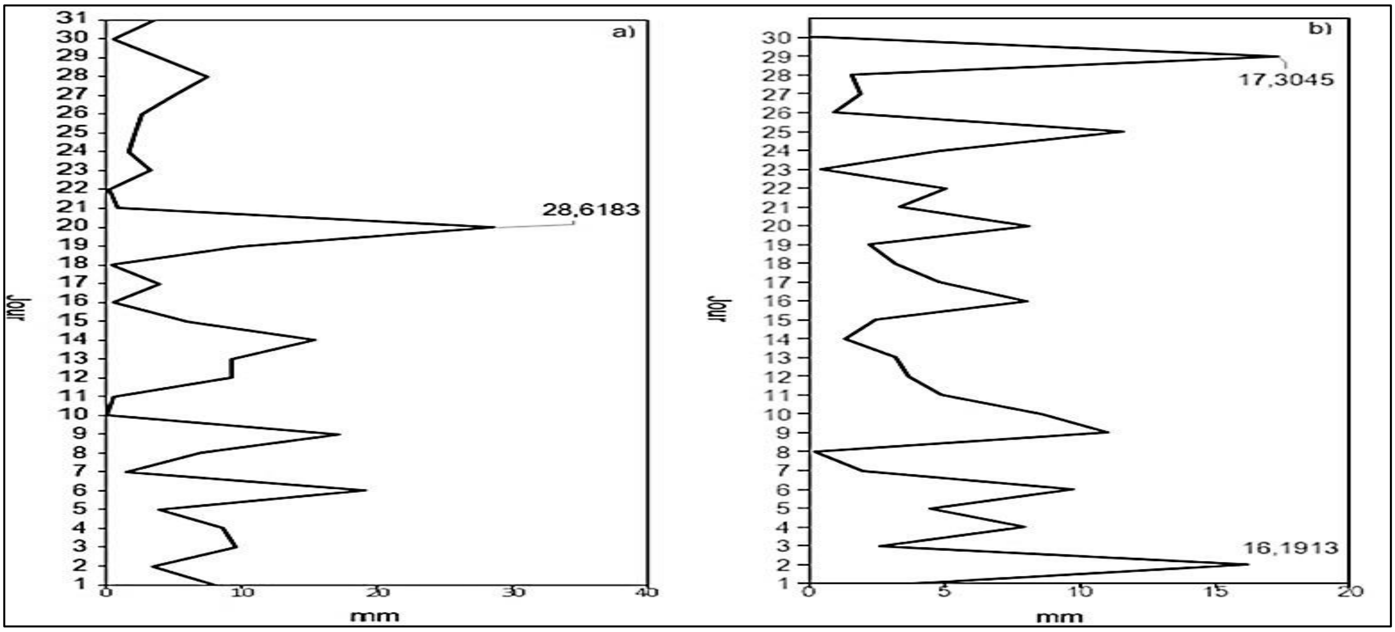

Fig 8 Cumulative daily rainfall at Epéna between October (a) and November (b) 2022.

Daily rainfall totals (considered high on a local scale) recorded in October and November 2022 are responsible for the flooding observed in the town Epéna on 20 October, 2022 (photos 1 and 2), and on November 2902 and, 2022 (photos 3, 4 and 5).


Photo 1: Flooding of a Plot of Land by rainfall on October 20, 2022 (Photo: Mamadou Mariame Jucelie, 2022)

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25jun955


Photo 2: Flooding of School Runway during the Rains of October 20, 2022 (Photo: Mamadou Mariame Jucelie, 2022)


Photo 3: Rain Flooding of the Main Road on November 2, 2022 (Photo: Mamadou Mariame Jucelie, 2022)

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25jun955

Photo 4: Flooding of Avenue Due Marche during the Rainstorm of November 29, 2022 (Photo: Mamadou Mariame Jucelie, 2022)

Photo 5: Flooded Plot and Roadway during the Rain of of November 29, 2022 (Photo Taken by Mamadou Mariame Jucelie, 2022)

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25jun955

IV. CONCLUSION

The aim of the present study is to analyze rainfall variability from 1980 to 2022 at Epéna and its impact on the rate of flooding observed between October and November 2022. The study shows that rainfall shows slight monthly and annual fluctuations, but is highly irregular seasonally. The daily rainfall totals recorded between October and November 2022 in Epéna are therefore responsible for the flooding observed during this period.

ACKNOWLEDGMENT

The author would like to thank the Center for Environmental Research and Studies for their logistical and financial support in carrying out this study.

REFERENCES

[1]. BIGOT S., MORON V., MELICE J-L., SERVAT E and PATUREL J- E., 1998, « Fluctuations pluviométriques et analyse fréquentielle de la pluviosité en Afrique Centrale », Century Proceedings Of The Abidjan 98 Conference Held At Abidjan, Côte D'ivoire, pp.71-78.

[2]. CAMBERLIN P., BARRAUD G., BIGOT S., DEWITTE O., MAKANZU IMWANGANA F., MAKI MATESO J-C., MARTINY N., MONSIEURS E., MORON V., PELLARIN T., PHILIPPON N., MUHINDO S. and SAMBA G., 2019, « Evaluation of remotely sensed rainfall products over Central Africa»,. QJRMeteorolSoc. pp.1-24. https://doi.org/10.1002/qj.3547

[3]. MPOUNZA M. and SAMBA-KIMBATA M-J., 1990, « *Aperçu sur le climat de l'Afrique centrale occidentale* In: *LANFRANCHI RAYMOND (ED.), SCHWARTZ DOMINIQUE* (ED.). *Paysages quaternaires de l'Afrique centrale atlantique* ». Paris: ORSTOM, pp. 31-41. (Didactiques). ISBN 2-7099-1022-5. ISSN 1142-2580.

[4]. SAMBA G. and MPOUNZA M., 2005, « Application du processus de Markov sur les occurrences des précipitations journalières au Congo-Brazzaville », Compte Rendu Géoscience (337) : pp.1355- 1364. https://doi:10.1016/j.crte.2005.07.010

[5]. SAMBA G. and NGANGA D., .2012, « Rainfall variability in Congo-Brazzaville 1932-2007», Int. J. Climatol. (32), pp854-873. https://doi:10.1002/joc.2311

[6]. TOLI G., 2020, « Évolution récente des précipitations diurnes à cumules élevées au nord- Congo (Congo-Brazzaville) », HAL-CNRS (revue en ligne), hal-02872897, 15p https://hal.archives-ouvertes.fr/hal-02872897

[7]. CAMBERLIN P., BELTRANDO G., FONTAINE B. and RICHARD Y., 2002, « Pluviométrie et crises climatiques en Afrique Tropicale : changements durables ou fluctuations interannuelles ? », Historiens& Géographes n°379, pp.263-273.

[8]. CAMBERLIN P., 2007, « L'Afrique Centrale dans le contexte de la variabilité climatique tropicale interannuelle et intrasaisonnière », Presses Universitaires d'Orléans, l'Afrique Centrale, le Cameroun et les changements globaux, Yaoundé, Cameroun. pp.25-39.

[9]. TOLI G. and SAMBA G., 2022, « Tendances et ruptures des précipitations sur la partie congolaise du Bassin du CONGO », Revue Espace Géographique et Société Marocaine, Vol.1, N°60, pp.181-197. https://doi.org/10.34874/IMIST.PRSM/EGDM/32318 .