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Analysis of Flood Risks Upstream from the Imboulou Hydroelectric Dam on the Léfini River, a Tributary of the Right Bank of the Congo River

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Abstract

The analysis of the risk of flooding upstream from the Imboulou hydroelectric dam on the Léfini River in the Republic of Congo-Brazzaville, focused on the evolution of annual rainfall and flow in the study area during the period from 1970 to 2020 before and after the building of the dam in 2005, by applying statistical methods. These methods were used to analyse the spatial and temporal evolution of rainfall and flow at the unique hydrometric station located at the RN2 (National Road N˚2) bridge in the village of Mbouambé in the Pool region. This work has shown that rainfall is not the cause of flooding in the Léfini catchment area. The monthly flow coefficient (MFC) showed exceptional flooding from November and December onwards after the dam was built, resulting in a variability of flows, with periods of high and low water. In addition, the annual average flow (AAF) and the maximum average flow (MAF) increased after the dam was built. Maximum average flows (MAF) were higher than annual average flows (AAF) throughout the period of study (1970-2020). The annual and monthly rainfall-runoff relationship showed changes after the dam was built, particularly from 2009 and during

the months of November and December.

Keywords

Léfini River, Imboulou Hydroelectric Dam, Floods, Monthly Flow Coefficient, Annual Average Flow, Maximum Average Flows

1. Introduction

The Léfini River is a tributary of the Congo River which is located on its right bank. It has its source at an altitude of 600 m in the Djambala plateau in the centre of Congo-Brazzaville, and drains a total catchment area of 14,727 km^2 at Imboulou hydroelectric dam before emptying out into the Congo River. Its interannual module (average flow calculated for a certain number of years) is 420 m^3/s. Several studies [1] [2] [3] have been carried out on the Léfini River, but this one focuses on the flooding it causes in the Mbouambé village. Indeed, since the filling of the Imboulou hydroelectric dam with water in 2005, few studies have been carried out to assess the adverse effects it causes, particularly flooding.

Although they are temporary situations that can be damaging (destruction of homes or plantations, for example) or beneficial (contribution of fertilising alluvium, for example), floods cause major economic losses for a country and lethal risks for the populations affected.

Nowadays more than 2.8 billion people worldwide are affected by floods [4]. The material damages caused have a significant impact on the living conditions of people affected by floods, through the deterioration of buildings (homes and strategic infrastructure such as hospitals and schools), the disruption or breakdown of networks (drinking water, sanitation, waste, energy, transport), the disruption or stoppage of economic activities, and the displacement of populations [1] [4].

Between 1971 and 1991, floods caused the deaths of 3 million people and disrupted the lives of 800 million others [5]. According to the Dartmouth Flood Observatory, in 2004 there were almost 200 major floods worldwide, responsible for the deaths of more than 200,000 people and the displacement of almost 51 million. Floods and rising capillarity very often result in the loss of property, the loss of many lives and the deterioration of the living environment.

In Africa, these phenomena are a topical issue, especially in urban areas and on the scale of catchment area. Indeed, flooding is a real concern, given that the continent's cities, already battered by poverty, regularly suffer the damage associated with this phenomenon. These cities are particularly hard hit because of the high density of their population and the fact that their development does not comply with urban planning standards. In Gabon, for example, some districts of Libreville have been facing increasing flooding problems for the past two decades, for the reasons mentioned above [6].

In addition, according to the Direction de la Protection Civile 2003, the floods that occurred in September 2022 in Cameroon, resulting in the death of nearly 20 people and the displacement of 40,000 others, only served to highlight the vulnerability of the national territory to this phenomenon.

Most of Central Africa's major cities along the Congo River and its tributaries (Brazzaville, Kinshasa, Bangui, Mossaka, etc.) are threatened by flooding, as almost thirty-nine million people live less than 1 km from a major watercourse. In the Republic of Congo-Brazzaville, according to a report of WFP [7], a total of around 3500 km^2 of land have been affected by floods in 2021. The floodwaters appear to have receded by around 300 km^2 during the period from 26 to 30 November 2021 (UNOSAT: United Nations Satellite Centre). Assessments carried out by the local authorities and humanitarian partners show that the rains over the last two months (November and December) have had a negative impact on agricultural crops, exacerbating the precariousness and poverty of the local population. According to the government authorities, 71,690 people were affected by flooding in October and November 2021 in the regions of Likouala, Cuvette, Plateaux and Sangha [7].

In all the areas liable to flooding, it was found that farmers use traditional cassava conservation systems that force them to harvest early cassava tubers planted before the period of rising water levels.

Flooding is the result of a combination of natural factors. In the case of the Léfini catchment, geomorphological predispositions, the extent of the hydrographic network and abundant and regular rainfall are all natural variables that condition the nature of the flood risk upstream from the Imboulou hydroelectric dam.

Since the Imboulou dam was filled with water, flooding has become a new phenomenon, particularly upstream of the river Léfini, in the village of Mbouambé-Léfini and the surrounding area. Local residents have testified that before the dam was built, and since the village was founded, it has never experienced such flooding. This phenomenon began to be observed after the dam was built, causing major changes in the hydrological regime of the Léfini river at its outlet [1].

Despite the various studies cited above, carried out in the Léfini catchment area, no research has been carried out on the Léfini River concerning the impact of the dam on its hydrological regime, resulting in flooding upstream of the river. This study aims to investigate the causes of flooding upstream from this dam.

2. Presentation of the Study Area

The Léfini catchment area is located between 14˚80' and 15˚12' latitude east and 2˚32' and 3˚35' longitude south (**Figure 1(a)** and **Figure 1(b)**), and covers an area of 13,500 km^2 at its hydrometeorological station in the village of Mbouambé (at the RN2 bridge). Its interannual module is 420 m^3·s^{-1} [8]. The Léfini watershed is bounded to the north by the Nkéni and Alima watersheds, to the south by the Djiri and Djoué watersheds, to the west by the Ndouo river watershed and to the east by the Congo River. The River Léfini rises at an altitude of 600 m in

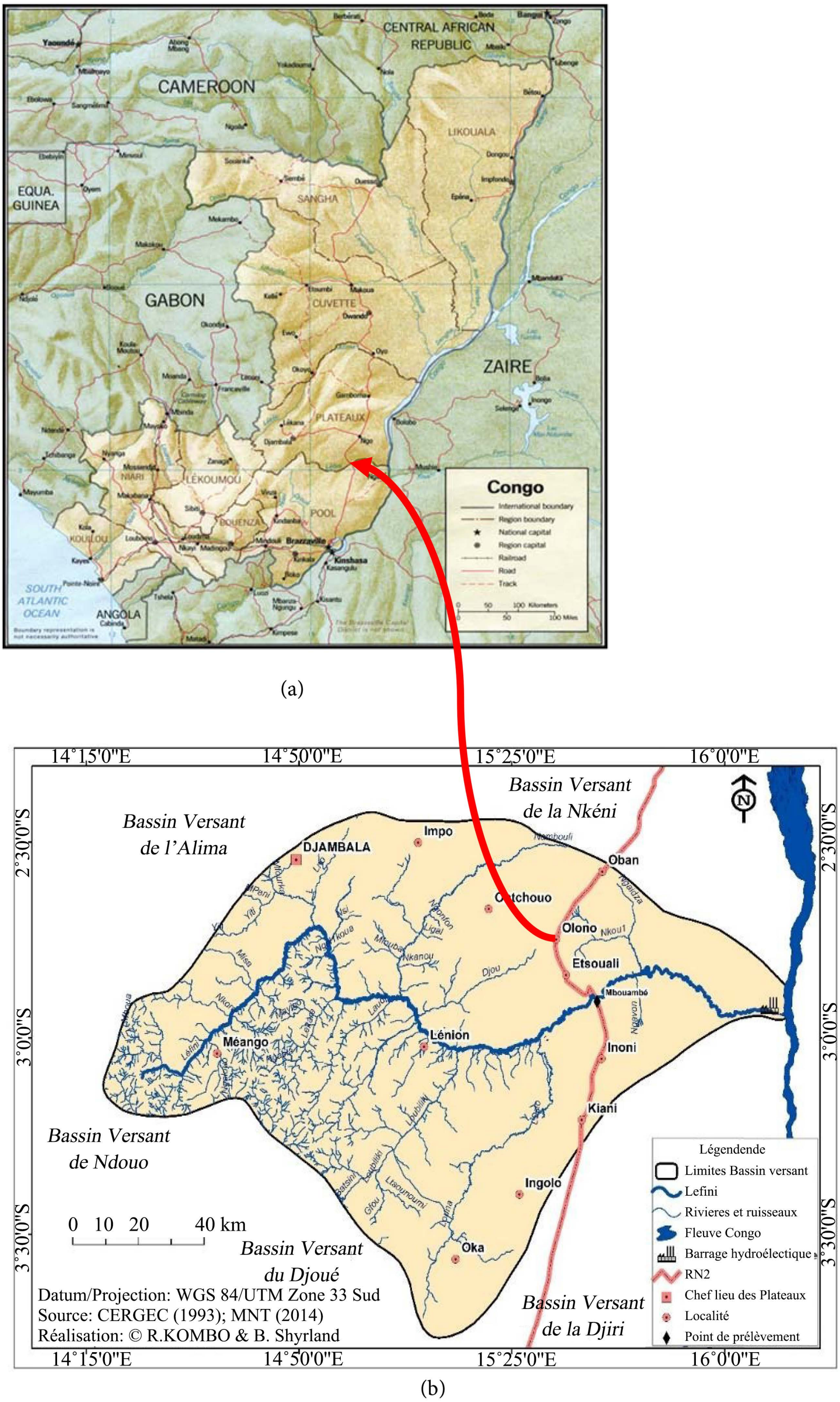

Figure 1. Geographical location of the Léfini catchment area: (a) Map of Republic of Congo; (b) Map of the Lefini catchment area.

the Djambala plateau, flows over a length of 250 km and empties out into the Congo River at an altitude of 285 m.

The Léfini catchment is influenced by a transition tropical climate with abundant rainfall, and average rainfall varying between 1600 and 2000 mm per year [8]. The typical vegetation of the watershed is a savannah with Loudétia demeusii, which can be transformed over large areas into a Trachypogon tholonu and *Hyparrhenia diplandra* savannah (Hydrological Yearbook of the Republic of Congo 1977 [8]). The river valleys are occupied by mesophilous forests. Most of the basin is made up of impoverished, yellow ferrallitic soils on sandy or sandy-clay material. Some secondary valleys also have podzolic ferrallitic soils on sandy material. The main valley is made up of hydromorphic mineral soils with pseudogley and gley, under sometimes very extensive gallery forest vegetation.

3. Data and Methods

3.1. Data

The data used for this study are rainfall data collected by the meteorological service of the Agence Nationale de l'Aviation Civile (ANAC) for the synoptic stations at Djambala and M'pouya, a rainfall station at Mbouambé and hydrometric data from the unique hydrometric station on the River Léfini at the Mbouambé village (**Figure 2**). These data are recorded in the collections of [2] [9], and supplemented by the data bank of the hydrological service of the National Institute for Research in Exact and Natural Sciences (IRSEN). These data were used to characterize the hydrological regime of the Léfini River, in order to determine the causes of flooding in the villages located in this basin. All these data are on monthly time scale for the common period from 1970 to 2020.

3.2. Methods

The methods applied in this study are those already used by several authors in different geographical areas.

The arithmetic mean method was used to fill in the gaps in the rainfall and hydrometric time series by applying Equation (1):

$$\overline{X} = \frac{\sum X_i}{N} \tag{1}$$

with

$\overline{X}$: the arithmetic average;

X_i: the value of each parameter studied;

N: the number of each parameter studied.

The method of regionalization was used in order to homogenize the rainfall data of the different stations (Djambala, M'pouya and M'bouambé) used. It consists in calculating the annual average rainfall for each time series in order to obtain a single matrix that will allow to make this study [10]. It is defined as an approach based on statistic relations with measurable properties over ungauged watersheds and which is used to estimate hydrometric data in a given area [11].

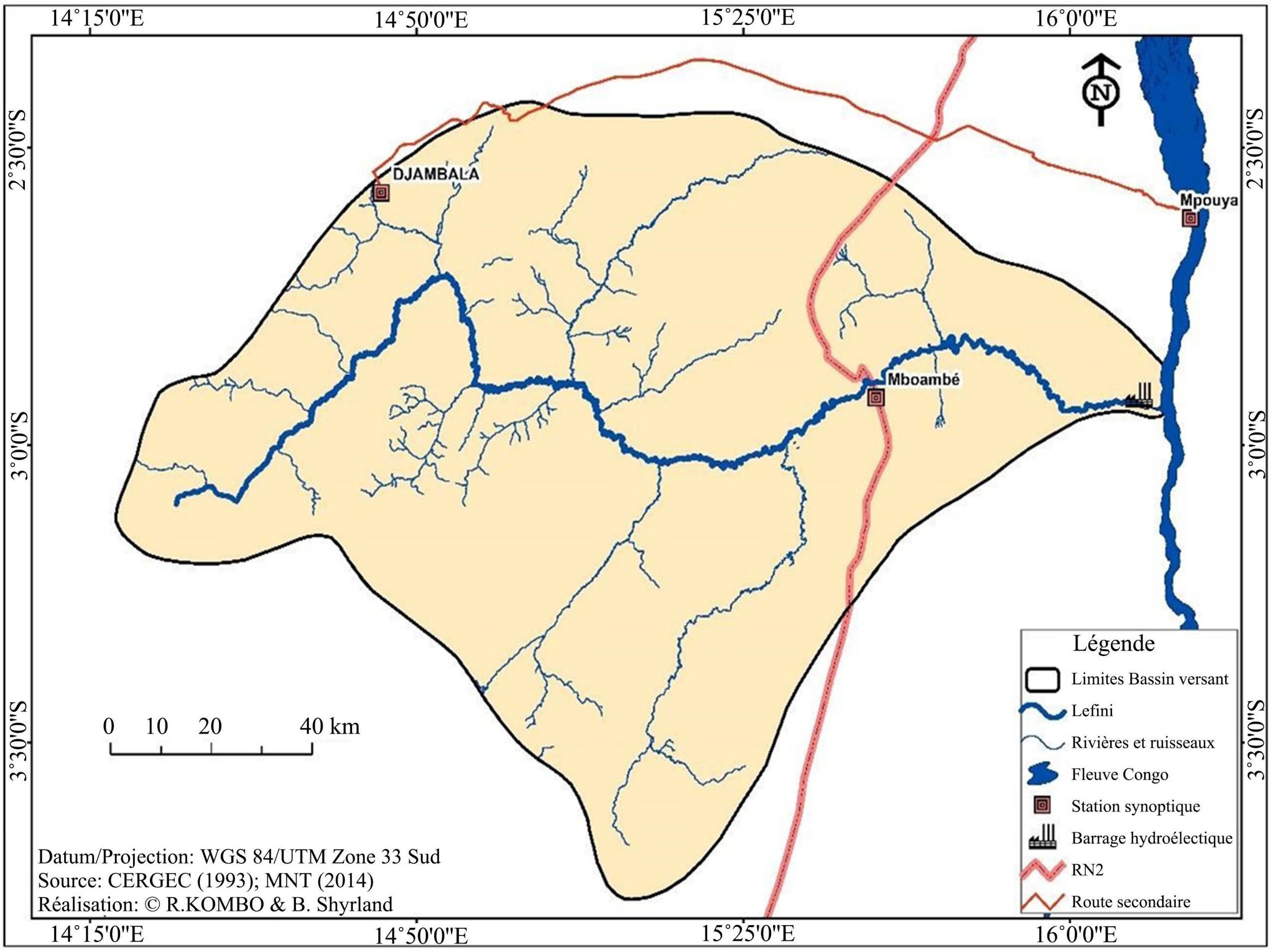

Figure 2. Hydrometric station of Mbouambé.

The control station method was applied to see the evolution of annual rainfall upstream from the dam measured at the same station for the period before and after the building of the Imboulou hydroelectric dam.

The monthly flow coefficient (MFC), which is the monthly rapport of the interannual, which allows repartition, of the monthly flows during the year, was calculated for the period before and after the building of the dam. This coefficient reflects the importance of a month over the year. It highlights the variability of flows, which is reflected in periods of high and low water. This coefficient is determined by the ratio of the monthly average flow (Q_m) to the interannual average flow or module (Q_{int}).

$$c = \frac{Q_m}{Q_{int}} \tag{2}$$

with

C: Monthly flow coefficient;

Q_m: monthly average flows;

Q_{int}: interannual average flow.

To obtain good results on flooding in the Léfini catchment area, an analysis of annual rainfall before and after the building of the dam was carried out. The flows is allowed to calculate the monthly flow coefficient before and after the dam was built.

In order to understand the evolution of flows before and after the building of the dam, one analyzes the annual average flows (AAF). The annual average flows is equal to the sum of the monthly values flows observed over the whole year divided by the number of the months.

Similarly, in order to understand the evolution of the extreme values of the flows before and after the building of the dam, one analyzes the monthly maximum average flows (MMAF). The monthly maximum average flows coefficient consists in selecting the highest value of flows during each year.

The rainfall-runoff relationship allowed to understand the evolution of rainfall and flow in the study area. It allows to make a comparison of the hydrological with rainfall time series.

The relative difference between monthly average of the flows before the building of the dam a and the flows after the building of the dam b in 2005, was also calculated in order to gain an appreciation of the flow values on the month, according to the Equation (3):

$$E = \left(\frac{a-b}{a}\right) * 100 \quad (3)$$

with:

a: monthly average flows before the building of the dam;

b: monthly average flows after the building of the dam;

E: relative difference between a and b.

4. Results

4.1. Trends in Annual Rainfall in the Study Area

Figure 3 and Figure 4 show the interannual changes in rainfall in the study area before and after the building of the dam over the period 1970-2020, in particular the periods 1970-2004 and 2005-2020.

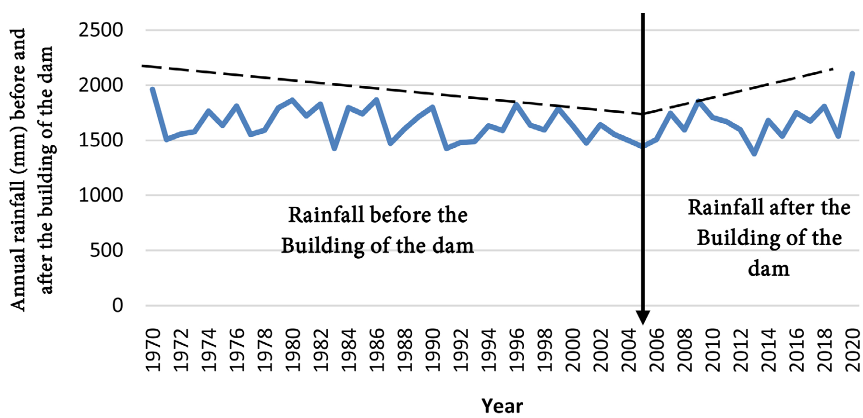

Figure 3. Rainfall before and after the building of the dam.

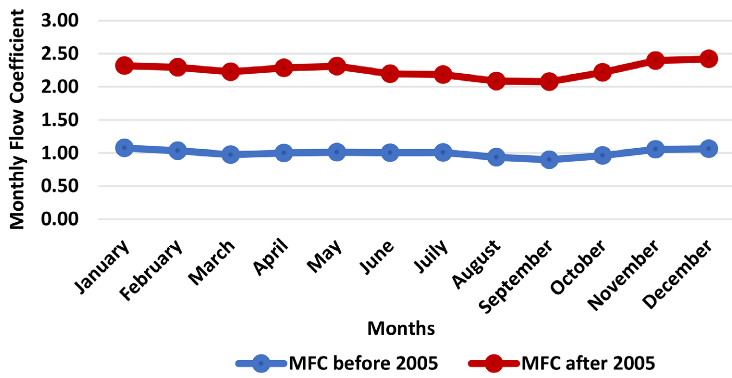

Figure 4. Monthly flow coefficient (MFC) in the Léfini watershed before and after 2005.

The study area is characterized by an annual rainfall between 1500 and 2000 mm with an average of 1652 mm before the building of the Imboulou dam, and between 1500 and 2100 mm with an average of 1661 mm after the building of the dam *i.e.*, a weak increase of 9 mm.

Before the dam was built (1970 to 2004), the general trend in rainfall was downwards (**Figure 3**). The years 1983, 1987 and 1991 were the least rainy compared with the others. However, for the period after 2004, *i.e.* from 2005 to 2020, the rainfall trend is slightly upwards (**Figure 3**). This is one of the reasons why water spreads to certain areas of the catchment that are not usually covered by water.

4.2. Changes in Flows in the Léfini Catchment Area before and after the Building of the Dam

Figure 4 shows the comparative results of the hydrological regimes (Monthly Flow Coefficient) before and after the building of the Imboulou hydroelectric dam in 2005.

The hydrological regime of the River Léfini is modelled on that of rainfall and the operation of the hydroelectric dam. Before 2005, flows in the Léfini River were decreasing throughout the period from 1970 to 2004 (**Figure 4**). After the dam was built, flows increased, with a slight decrease observed from June to September. However, these flows became greater (2.2) in November and December onwards, when rainfall reached its peak. In fact, these months see exceptional high water levels after the building of the dam, leading to flooding.

Table 1 shows the evolution of the relative differences between monthly average flows in the periods before and after the building of the dam in 2005. After the dam was built, flooding became a common occurrence in the Léfini catchment area. This clearly shows that flows are higher after the building of the dam than in the period before. These high values are the direct consequence of the heavy rainfall observed after the dam was impounded. The highest values were observed in January, February, May, November and December. These facts show that there were significant differences in flows between the two periods (before and after the building of the dam).

Table 1. Evolution of the relative differences between monthly average flows in the periods before and after the building of the dam in 2005.

Months	Monthly average flows before 2005	Monthly average flows after 2005	Relative difference
Jan	426	631	326
Feb	409	641	309
March	385	636	285
April	396	652	296
May	401	660	301
June	397	605	297
July	399	596	299
August	370	584	270
Seven	356	598	256
Oct	380	638	280
Nov	418	682	318
Dec	421	689	321

4.3. Variability of Annual Average Flows and Maximum Average Flows

Figure 5 and **Figure 6** show changes in annual average flows (AAF) and monthly maximum average flows (MMAF) at the M'Bouambé station before and after the building of the dam.

As far as annual average flows (AAF) are concerned, the pre-dam period (1970-2004) shows a slight drop in flows of less than 4% from the 1970s to 1995, including 1998, 1999, 2003 and 2004. On the other hand, for the post-dam period (2005-2020), the AAF show a slight increase at the beginning of 2010 with a flow value greater than 200 m^3/s

Analysis of the MMAF shows a downward trend in the pre-dam period (1970-2004) and an upward trend in the post-dam period (2005-2020) upstream of the Léfini River. In the pre-dam period, after the long rainfall deficit of the 1970s, there was a slight drop in MMAF from the 1980s to 1994, with a maximum flow value of 432 m^3/s. From 1995 to 2002 there was an increase in flows, with a maximum of 594 m^3/s. These MMAF fell in 2003 and 2004, with flow values of 527 and 360 m^3/s. The MMAF observed after the building of the dam (2005-2020) show an upward trend, which is confirmed on the trend curve of **Figure 6** who shows a slight increase in flows from 2005 to 2007, with a maximum value of 375 m^3/s. From the end of 2007 to 2009, flows decreased to 328 m^3/s. From the end of 2009 we see a marked increase in maximum flows until 2020 with a value of 733 $m/s.^3$

Generally speaking, the MMAF showed an upward trend (**Figure 5**) with a flow value of 626 m³/s in 2000 before the dam was built. On the other hand, after the dam was built, the MMAF showed a marked increase, reaching a value of 600 m³/s and barely exceeding the maximum flow of 713 m³/s observed in 2020. The AAF showed a drop in flows before the dam was built, from 419 m³/s to 321 m³/s, and an increase of 702 m³/s in annual average flows after the building of the dam. This represents a positive difference of 30% in flows.

The figures below illustrate changes in mean annual flows and maximum flows before and after construction of the hydroelectric dam.

Figure 7 illustrates the evolution of mean annual flows over the period 1970 to 2020 before and after construction of the dam. Before the dam was built, mean annual flow values reached 400 m³/s over the period 1970 to 2004. After 2004, there was a fall in flow values to 289, 291, 305, 304 and 296 m³/s for the years 2005, 2006, 2007, 2008 and 2009. From 2010 onwards, we see an increase in flow values until 2020. In general, the MAF before the dam was built was higher than the MAF after the dam was built.

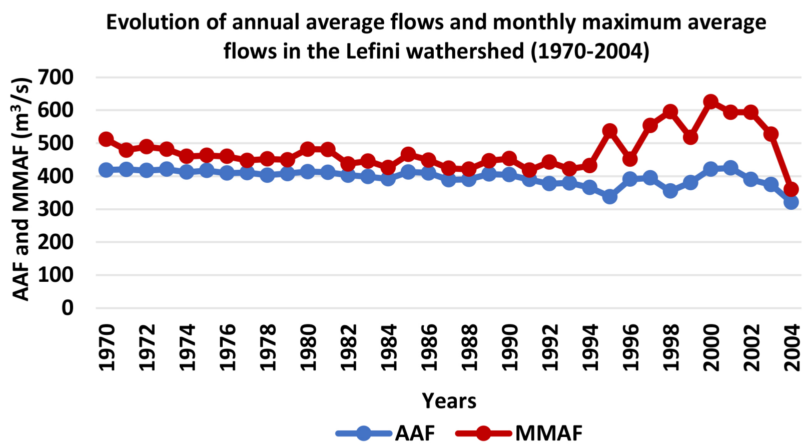

Figure 5. Evolution of annual average flows (AAF) and monthly maximum average flow (MMAF) in the Léfini watershed before the building of the dam.

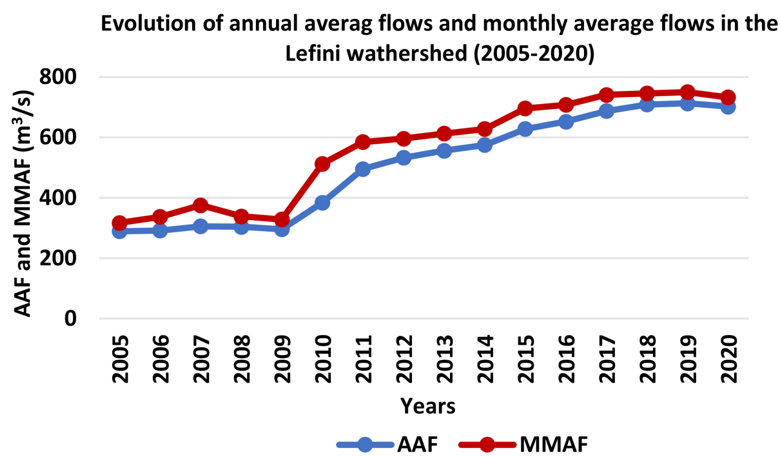

Figure 6. Evolution of annual average flows (module) and monthly maximum average flows in the Léfini watershed after the building of the dam.

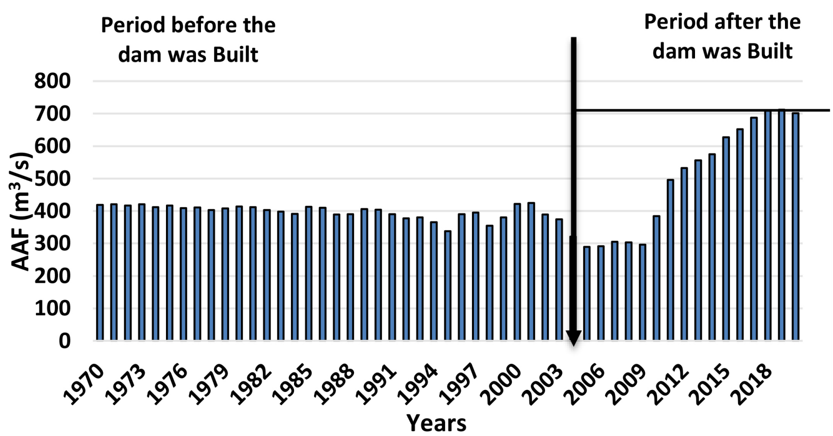

Figure 7. Evolution of annual average flow (AAF) in the Léfini watershed before and after the building of the dam.

Figure 8 shows the evolution of maximum flows over a period from 1970 to 2020 in the Léfini catchment area. Before the dam was built, *i.e.* from 1970 to 1994, maximum flow values varied between 432 m^3/s and 512 m^3/s. From 1995 to 2004 there was an increase in maximum flows, with values ranging from 400 m^3/s to 626 m^3/s. Between 2005 and 2009, the maximum flows were between 316 and 328 m^3/s, and from 2010 onwards the maximum flows will increase until 2020. After the dam was built, maximum flows were higher than before the dam was built.

4.4. Rainfall-Runoff Relationship

Rainfall-runoff relationships are highlighted by analysing the impact of climate variability on surface water resources, in order to identify the climatic contribution and the anthropogenic contribution [8].

Generally speaking, any hydraulic development, such as the building of dams, weirs, bridges and many other infrastructures, can disrupt the flow regime of a watercourse. In the context of this study, the rainfall-runoff relationship allows to analyse the link between rainfall and flow. In other words, the rainfall-runoff relationship will enable us to monitor changes in the hydroclimatic behaviour of the Léfini River by highlighting, on the one hand, the rainfall effects and, on the other hand, the effects that are probably linked to the Imboulou dam.

Figure 9 and **Figure 10** illustrate the relation between the rainfall and flows in the Léfini River on annual time scale before and after the building of the hydroelectric dam over the period 1970 to 2020. Before the dam was built (**Figure 10**), flows had the same annual variations as rainfall over the period 1970 to 2004, with the highest rainfall value being 1962 mm in 1970, while flows reached a value of 425 m^3/s in 2001. These values then gradually decreased to 1498 mm of rainfall and 321 m^3/s of flows in 2004. In general, the period before the dam was built shows a downward trend, which is confirmed in **Figure 9**.

The period after the building of the dam (**Figure 10**) shows an upward trend in flows. Up until 2008, the flow and rainfall curves show the same variations,

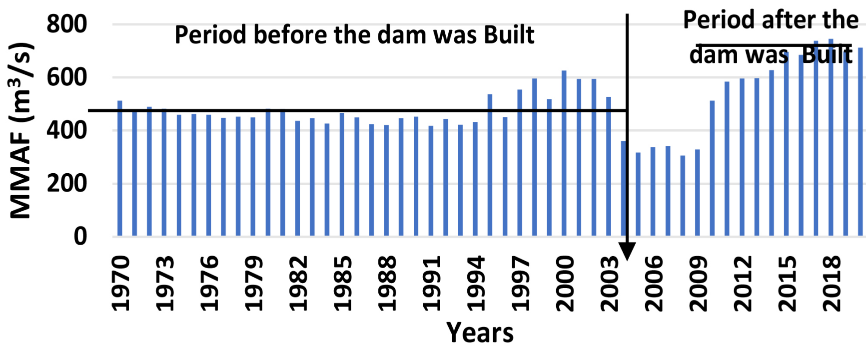

Figure 8. Evolution of monthly maximum average flow (MMAF) in the Léfini watershed before and after the building of the dam.

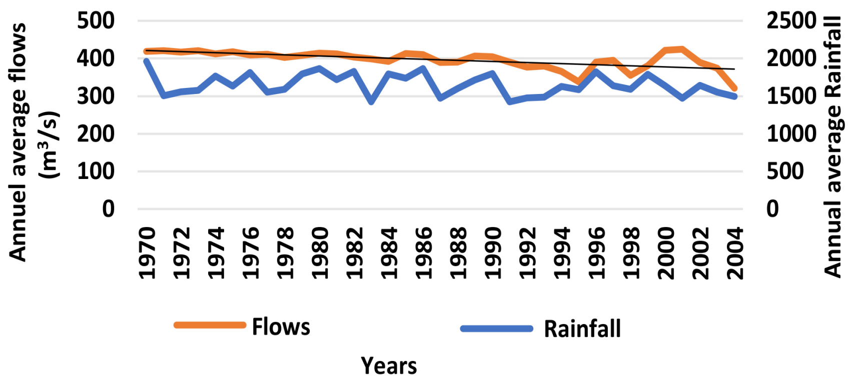

Figure 9. Rainfall and average annual flows before the dam was built.

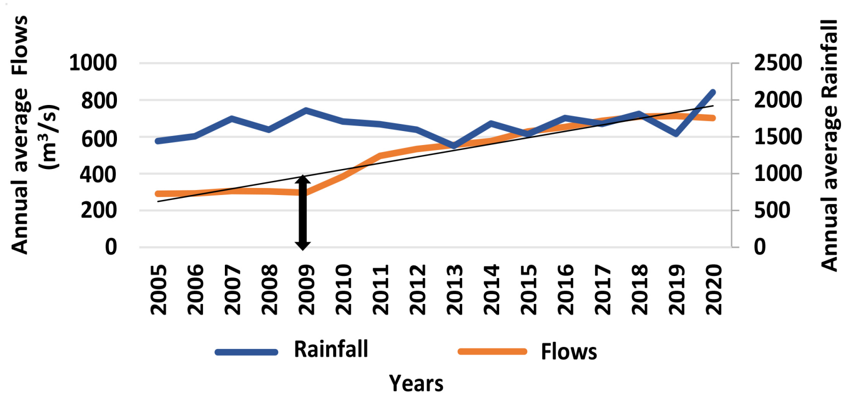

Figure 10. Rainfall and average annual flows after the dam was built.

but it is only from 2009 onwards that one sees an increase in flow until 2020. This increase from 2009 onwards has the same variations as rainfall until 2013, when the flow values start to increase according to rainfall, from 296 m^3/s in 2009, 384 m^3/s in 2010, 496 m^3/s in 2011, 533 m^3/s in 2012 and 556 m^3/s in 2103. While rainfall was stable from 2014 to 2020, flows increased steadily. These facts indicate that flows are not always sustained by rainfall. It is possible that groundwater feeds the river during periods when it is not raining, or that human activities such as the building of the dam are responsible for an increase in the water level in the river.

A comparison of the rainfall and hydrological regimes of the Léfini River at Mbouambé station on an annual time scale shows the annual variations in rainfall and flows in the periods before and after the building of the dam. For the pre-dam period, Figure 9 shows that the flows and annual rainfall have the same variations over the period (1970-2004). The highest rainfall value was 1962 mm in 1970, while interannual flows reached a value of 425 m^3/s over the entire period.

After the dam was built (Figure 10), it was observed that until 2009 the flows curve and that of rainfall had the same variations. After 2010, one observed a sudden increase in flows curve upstream from the dam, which was different from the trend in rainfall.

Flow values increase from 2010 to 2020, with values varying between 480 m^3/s in 2010 and 702 m^3/s in 2020, while rainfall remains stable.

Figure 11 and Figure 12 show that the monthly trend in flows is closely matched to that of rainfall. Rainfall has been falling over the two sub-periods (1971-2004 and 2005-2020). This drop in rainfall begins in May and ends in September during the dry season. The fall in flows, on the other hand, began two months later before the dam was built and kept pace with the rainfall after the dam was impounded.

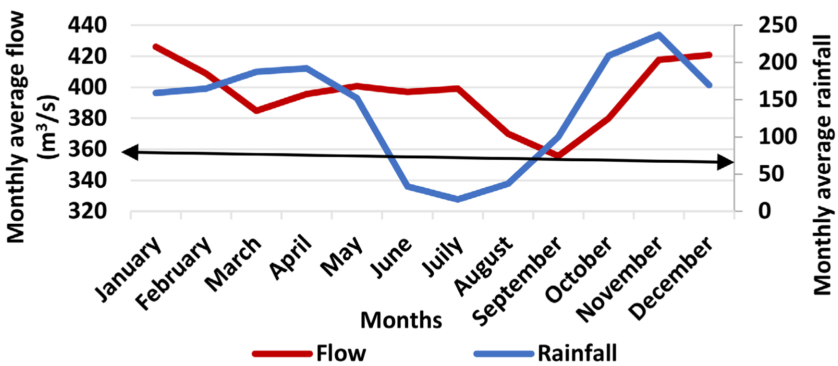

Figure 11. Rainfall-runoff relationship on monthly time scale before the dam was built (1970-2004).

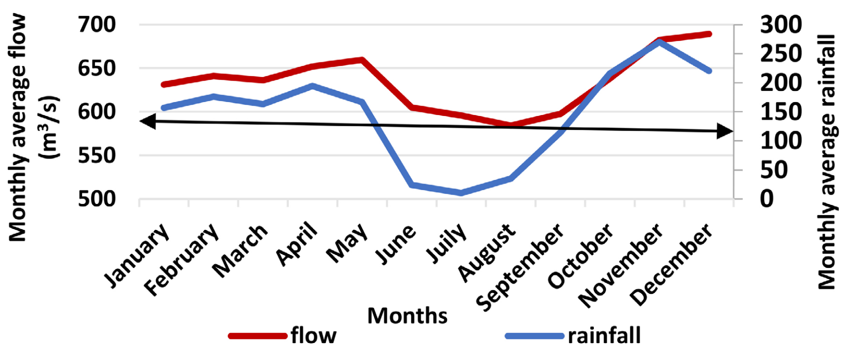

Figure 12. Rainfall-runoff relationship on monthly time scale after the dam was built (2005-2020).

This observation shows that rainfall has a bimodal regime in the two sub-periods. The first peak is observed in April (192 mm of rainfall in the pre-dam period and 195 mm of rainfall in the post-dam period) and the second in November (237 mm of rainfall in the pre-dam period and 270 mm of rainfall in the post-dam period). Before the dam was built the flows ranged from 356 m^3/s in September to 426 m^3/s in January. After the building of the dam, the peaks are observed one month after rainfall (from 660 m^3/s in May to 689.3 m^3/s in December), and the lowest flow value is 584 m^3/s in August. Thus, one can conclude that rainfall is also one of the causes of the increase in the water level of the Léfini River, leading to the flooding observed upstream from the hydroelectric dam, more specifically in the village of M'bouambé and its immediate surroundings.

5. Discussion

With an area of 14,727 km^2 up to the dam, the Léfini catchment area is dependent on a transition tropical climate with a bimodal rainfall regime. Rainfall trends over the period 1970-2020 on an annual time scale show a slight downward trend from the 1970s, over the pre-dam period 1970-2004 (**Figure 3**). These years are characterized by a drop in rainfall. These results are in line with those found by Paka [1] in the same watershed.

However, the post-dam period shows the opposite phenomenon. Rainfall shows an upward trend ((**Figure 3**) from 2005 to 2020. This increase in rainfall over the period 2005-2020 can be explained by an improvement in annual rainfall from 2006 onwards. This phenomenon has been observed by other authors since the late 1980s, including unpublished dissertation made by Houanye A.K., (2003) at University of Liège (Belgium), on the increasing trend in annualrainfall in the lower Ouémé basin in Benin and elsewhere in West Africa [12] [13]. The same results were obtained by [14]. On a regional scale [15] [16] [17] [18] [19] underlined the importance of this rainfall change in the Sahelian region, which also affected the Sudanian zone.

Variation of flows in the Léfini catchment area, before and after the building of the dam presents important results on the hydrological regime of this river. The monthly flow coefficients (MFC) observed at the Mbouambé hydrological station show that after the dam was built, the MFC values are higher than those obtained before the dam was built. The difference is due, among other things, to the presence of the dam, which caused significant changes in flows after 2004. These facts were observed by [20] on the Mono River (Togo-Benin) in West Africa.

The variability of annual average flows (AAF) and monthly maximum average flows (MMAF) show the changes in hydrological regime at the M'Bouambé station before and after the building of the dam (**Figure 5** and **Figure 6**).

In general, it is noted that the climatic deterioration of the 1970s has been felt both in terms of AAF and MMAF in the Léfini watershed. A slight increase in

MMAF was observed from 537 m^3/s in 1995 to 594 m^3/s in 2002, with a peak of 626 m^3/s in 2000. A slight decrease of 527 m^3/s and 360 m^3/s is observed respectively in 2003 and in 2004. From1996 to 2001, AAF have values between 391 and 425 m^3/s (**Figure 5**).

On the other hand, the post-dam period is marked by relatively stable flow rates (MMAF and AAF) from 2005 to 2009 with values of 317 m^3/s to 328 m^3/s for MMAF and 289 m^3/s to 296 m^3/s for AAF. From 2009 to 2020, there was a significant increase in MMAF and AAF reaching maximum values of 733 m^3/s for MMAF, and 702 m^3/s for AAF (**Figure 6**).

In general, during the period from 1970 to 2020, the AAF after the building of the dam are higher than those before the building of the dam (**Figure 7**). Similarly, the MMAF after the building of the dam are higher than the MMAF before the building of the dam (**Figure 8**).

Figure 9 and **Figure 10** show trends in flows before and after the dam was built over the period 1970 to 2020. There was a downward trend in flows prior to dam was built (1970 to 2004) and an upward trend on annual average flows after dam was built (2005 to 2020).

The rainfall-runoff relationship on monthly time scale in the Léfini catchment area shows a drop in rainfall that begins in May and ends in September (before and after the building of the dam). On the other hand, the drop in flows begins two months later than the drop in rainfall before the dam was built, but at the same month after the dam was impounded. These results indicate that the monthly evolution of flows is modelled on the rainfall regime.

These illustrations show two peaks in the two subperiods. The flows show two peaks in the same months as the rainfall before the dam was built, while after the dam was built, the flow peaks are observed one month after the rainfall peak. This means that the hydrograph of the Léfini river is bimodal. These results were also observed by Paka J.A. in 2013, in his Master thesis at Marien Ngouabi University of Brazzaville (Congo), in the catchment area of the Loufoulakari, a river running through the Plateau des Cataractes to the south of Brazzaville (Congo).

6. Conclusions

The study of flood risk upstream from the Imboulou hydroelectric dam on the Léfini River, a tributary of the right bank of the Congo River, was carried out using rainfall data from the Djambala, M'pouya and M'bouambé stations, and hydrometric data from the unique Mbouambé hydrological station from the period 1970 to 2020. Statistical tests were used to fill in missing data. The regionalization method was used to homogenize the data. In addition to this method, the monthly flow coefficient (MFC), the relative difference method (E), the annual and monthly rainfall-runoff relationship, and the comparison of annual average flow (AAF) and maximum average flow (MMAF) were used to understand the flooding phenomenon in the Mbouambé-Léfini village. The results obtained during this study enabled to understand the hydrological functioning of the Léfini River before and after the building of the Imboulou hydroelectric dam.

Analysis of the hydrological regime of the Léfini River over the 51-year period from 1970 to 2020, shows that changes following the construction of the Imboulou hydroelectric dam in 2005 have significantly modified the interannual variability of its module. Maximum flows have changed from the period before the dam was built to the period after. The dam therefore has an influence on maximum flows.

Rainfall is not the only cause of the change in the hydrological regime; it is also due to the presence of the dam, which contributes to the increased silting up of the River Léfini, causing the movement of suspended matter and an increase in the water level, resulting in the flooding of riverside communities and plantations.

In addition to the increase in rainfall since the late 1980s, human pressures and demographic growth explain the increase in the frequency of flooding observed in recent years upstream of the Imboulou dam in the post-dam period. The increase in population and the absence of a proper land management policy have led to soil degradation, deforestation of riverbanks and flood-prone areas, not to mention an increase in the amount of land planted with crops and an increase in the number of dwellings in non-constructible areas.

Flooding makes local populations vulnerable because of the damage it causes in the Léfini catchment area. It is therefore important to raise awareness among local authorities so that they develop alternative flood management strategies. This requires the design of an effective land-use plan, its application and, above all, compliance with it.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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