CLIMATIC EXTREMES AND RICE PRODUCTION IN THE BONGOUANOU DEPARTMENT, CENTRAL-EAST CÔTE D'IVOIRE

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Summary

Climate variability is noway an undeniable reality. It is manifested through climatic extremes including rising average temperatures and the changes in rainfall patterns, affecting all sectors of activity. The agricultural sector remains the most vulnerable due to its heavy dependence on climatic conditions. Rice paddy, especially rain-fed, is one of the activities most sensitive to climatic extremes. Indeed, the variation in weather conditions can be detrimental to rain-fed rice, thus leading to crop losses. This study focuses on the specific case of the Bongouanou department. Its objective is to analyze the evolution of climatic conditions and to evaluate their impacts on rice production in this department. The methodology relied on documentary research and field surveys. The documentation concerned both general and specific works related to climate and rice farming. The field survey consisted of direct observations and the administration of a questionnaire to 131 rice farmers. The results reveal an upward rainfall trend between 1970 and 2024. In addition, temperatures and PET (Potential Evapotranspiration) show an annual increase, disrupting agricultural calendars and local water regimes. Despite increasing rainfall, rice production gradually declined, falling from 1379 tons in 2015 to 1151 tons in 2024. This decrease is weakly correlated with rainfall variations (09.92%) and changes in water regimes (10.47%), while the increase in PET explains 09.45% of the yields reduction. Finally, according to farmers' perceptions, the main impacts of climate variability are reflected in delayed sowing (89.68%), the practice of a single cropping cycle (88.10%), and the occurrence of drought during rice growth (81.75%).

Keywords : Côte d'Ivoire, Bongouanou, Climatic extreme, Rice production

EXTRÊMES CLIMATIQUES ET PRODUCTION DU RIZ DANS LE DÉPARTEMENT DE BONGOUANOU, CENTRE-EST DE LA CÔTE D'IVOIRE

Résumé

La variabilité climatique est aujourd'hui une réalité incontestable. Elle se manifeste par des extrêmes climatiques dont l'augmentation des températures moyennes et la modification des régimes pluviométriques, affectant l'ensemble des secteurs d'activité. Le secteur agricole reste le plus vulnérable en raison de sa forte dépendance aux conditions climatiques. La riziculture, surtout pluviale est l'une des activités les plus sensibles aux extrêmes climatiques. En effet, la variation des conditions météorologiques peut être préjudiciable au riz pluvial, entrainant ainsi la perte des récoltes. La présente étude s'intéresse au cas spécifique du département de Bongouanou. Elle a pour objectif d'analyser l'évolution des conditions climatiques et d'évaluer leurs impacts sur la production du riz dans ce département. La méthodologie s'est appuyée sur la recherche documentaire et les enquêtes de terrain. La documentation a concerné les ouvrages généraux et spécifiques relatifs au climat et la riziculture. L'enquête de terrain a consisté en des observations directes et l'administration d'un questionnaire auprès de 131 riziculteurs. Les résultats révèlent une tendance pluviométrique à la hausse entre 1970 et 2024. En outre, les températures et l'ETP présentent une hausse interannuelle, bouleversant les calendriers agricoles et les régimes hydriques locaux. Malgré l'augmentation des pluies, les productions rizicoles ont connu une baisse progressive passant de 1379 tonnes en 2015 à 1151 tonnes en 2024. Cette diminution est faiblement corrélée aux variations pluviométriques (09,92%) et aux modifications des régimes hydriques (10,47%), tandis que la hausse des ETP explique à 09,45% la baisse des rendements. Enfin, selon perceptions paysannes, les principaux impacts de la variabilité climatique se traduisent par le retard des semis (89,68%), la pratique d'un cycle unique (88,10%) et la survenue de sécheresse pendant la croissance du riz (81,75%).

Mots clés : Côte d'Ivoire, Bongouanou, Extrême climatique, Production du riz

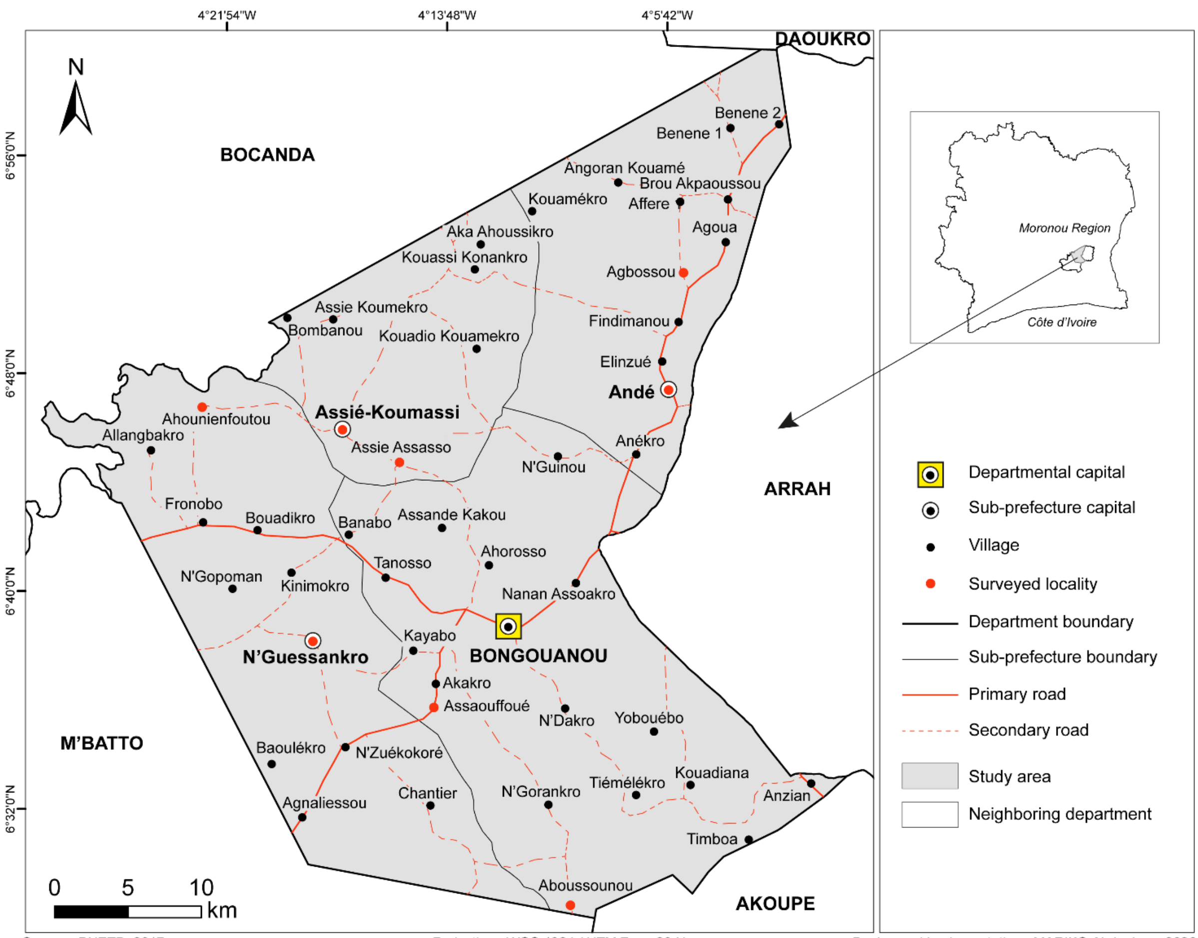
Introduction

Climate change today constitutes an observable reality, characterized by global warming and the increase in climate hazards which lead to a greater variability of climate elements (P. Kouadio, 2022, p. 16). In West Africa, this variability manifests as recurrent and irregular droughts, disruptions in rainfall patterns with rainfall deficits of around 20% to 30%, and a decrease in river flows (M. Diomandé et *al*., 2008, p. 2). In Côte d'Ivoire, climate variability has been manifested by a decrease in precipitation, which began at the end of the 1960s, intensified during the 1980s and 1990s, before experiencing a slight improvement in the 2000s (B. Yao et *al*., 2005, p. 533). However, these shifts are not without consequences on agriculture, which is heavily dependent on water (IPCC, 2007, p. 2). Their impacts can be more pronounced in certain regions due to the high spatial variability of the climate (M. Ouédraogo, 2012, p. 4). Rainfed rice cultivation is among the agricultural activities most exposed to this climatic variability, while rice is a staple for food security (P. Yao, 2022, p. 176). In the Moronou region, more specifically in the Bongouanou department, climatic conditions experience notable variations. This modification affects both rice cultivation and its production. However, how do extreme climatic conditions impact rice production in the Bongouanou department ? This study aims to analyze the evolution of climatic conditions and to evaluate their impacts on rice production in this department.

1. Materials and Methods

1.1. Spatial Framework

The former N'Zi-Comoé region underwent an administrative division into three distinct regions, namely the N'Zi, Iffou, and Moronou regions, through decree n°2012-612 of July 4, 2012 (A. Koulaï et *al*., 2022, p. 815). The Moronou region is composed of three departments, namely Arrah, Bongouanou, and M'Batto. The Bongouanou department, which constitutes the spatial scale of the present study, is located precisely between the coordinates 4°21'54'' and 4°5'42'' West longitude and 6°32'00'' and 6°56'00'' North latitude (Figure 1). The Bongouanou department has a growing and rapid demographic dynamic. Its population increased from 165,307 inhabitants in 2014 to 193,158 inhabitants in 2021, an increase of 27851 inhabitants with a growth rate of 16.85% from 2014 to 2021 (ANSat, RGPH, 2014 and 2021). This department benefits from natural conditions favorable to both industrial and subsistence agriculture. Rice is one of the main cereal crops grown by the local population.



Source : BNETD, 2017 *Projection : WGS 1984 / UTM Zone 30 N* *Design and implementation : MARIKO Abdoulaye, 2026*

Figure 1 : Location of the Bongouanou Department

1.2. Data Collection Method

The collection of data study required research on bibliographic data, statistical data, and field surveys.

1.2.1. Documentary Research

It consisted of reading works that address issues of climate variability and rice at various spatial and temporal scales. The consulted works are two types, namely general works and specific works. They were consulted online and in the libraries of Peleforo GON COULIBALY University in Korhogo.

1.2.2. Collection of Statistical Data

Various statistical data were used for the conduct of the study. First, demographic and cartographic data were provided respectively by AnSat (National Statistics Agency) and BNETD (National Bureau for Technical Studies and Development). Then, statistical information on rice production was provided by ADERIZ (Agency for the Development of the

Rice Sector in Côte d'Ivoire). Finally, climatic data, including Potential Evapotranspiration (PET), Temperatures (T), and Rainfall (R), were downloaded from websites such as http://ww.cru.uea.ac.uk/cru/data/hrg/ and https://app.climateengine.org.

1.2.3. Field Surveys

Two main techniques were used to collect primary data. These are direct observation and surveys by questionnaire. Direct observation allowed an understanding of the realities of local rice cultivation and to take illustrative shots. As for the survey by questionnaire, it was conducted with rice farmers according to the purposive sampling technique. To do this, all the sub-prefectures of the department were included in the survey. Thus, in each of them, two localities were selected based on the guidance provided by the ADERIZ delegates in the Moronou region. In each locality, 18 rice farmers were selected. The selection of rice farmers was facilitated with the support of the focal points of the ADERIZ delegates. In total, the survey covered 8 localities with a total of 131 rice farmers, as the intended number could not be reached in Assié-Assasso, where only 5 producers could be interviewed due to the decline of rice farming in this village. The processing of the collected data was made possible through the use of several techniques and software.

1.3. Data processing method

The software used for the processing includes Word 2016 for text entry, and EXCEL 2016 and XLSat 2014 for processing climate data and field survey data.

1.3.1. Processing of climate data

The determination of rainfall trends from 1970 to 2024 was carried out through the calculation of the Nicholson index. The calculation of the rainfall index was done using the following formula :

$$Ii = \frac{(Xi - X)}{\sigma}$$

Where

Ii = Rainfall index,

Xi = Cumulative of the studied year i,

X = Average rainfall over the reference period,

σ = Standard deviation of the variable over the same reference period.

The crossing season determination, the method proposed by Franquin (1969) was used. Thus, according to studies carried out by P. Franquin (1969, p. 72) and M. Eldin (1989, p. 57), the cropping season is subdivided into several periods (Figure 2) with different interpretations :

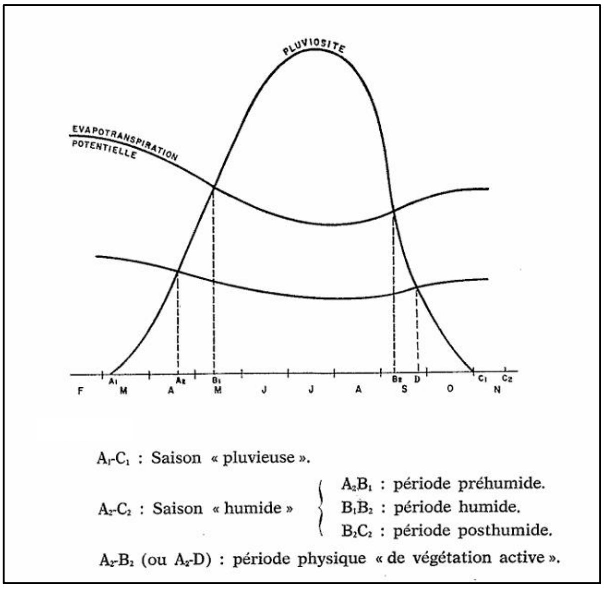


Figure 2 : Agricultural calendar according to P. Franquin

Source : P. Franquin, 1969, p. 72

- R < PET/2 : Refers to the period of preparation of agricultural plots. This phase, noted A1-A2, corresponds to the dry season but starts from C1-C2 just after the harvests.
- R > PET/2 : It is called pre-wet and corresponds to the period of wet sowing, but important for germination, emergence, and the beginning of growth. This period (A2-B1) is favorable for crop growth without meeting the needs corresponding to its full development.
- R > PET : This phase (B1-B2), called wet, corresponds to the period of meeting the plant's water needs. It characterizes the active vegetation phase.
- R < PET : Constitutes the post-wet period and corresponds to the period of water deficit. During this period (B2-D), the water supply allows meeting the needs for maturation.

Finally, the Aridity Index was used to characterize the evolution of the water balance in the Moronou region over the period from 1970 to 2024. Indeed, the aridity index according to the UNESCO (1979) approach makes it possible to assess the degree of water deficit or surplus. This method is adopted by B. Diomandé et *al*., (2014, p. 30) in their study, under the name of the Drought Index. According to them, it is a method that consists of classifying climates or different ecological environments. It is obtained by applying the following mathematical formula :

DI = R/ PET

With :

- ✓ DI : the Drought Index
- ✓ R : the average precipitation of the decade ;
- ✓ PET : the average amount of water evaporated over the period.

B. Diomandé et *al*., (2014, p. 30) provide the classification of drought indices as follows (Table 1) :

Table 1 : Classification of climate types or ecological environment based on drought index values

Value of the drought index	Climate qualification or ecological environment
DI < 0,05	Hyper-Arid
0,05 < DI < 0,25	Arid
0,25 < DI < 0,50	Semi-Arid
0,50 < DI < 0,75	Subhumid
0,75 < DI < 1	Humid
DI > 1	Hyper-Humid

This method made it possible to study the evolution of ecological environments according to decades during the period from 1970 to 2024.

1.3.2. Correlation processing

For the present study, it was necessary to analyze and evaluate the link between climatic factors and rice production in the department. Thus, the Bravais-Pearson regression test was used. This correlation allows measuring the intensity of the connection between two quantitative characteristics. However, a zero coefficient (r = 0), thus indicating the absence of a linear relationship between the variables, does not exclude the existence of a relationship other than linear. Moreover, the coefficient is positive if the relationship is positive (direct, increasing) and negative if the relationship is negative (inverse, decreasing). This coefficient ranges between -1 and +1. Consequently, the intensity of the linear relationship is all the stronger if the coefficient value is close to +1 or -1, and all the weaker if it is close to 0.

2. Results

The results of this study are presented in three main points. They first analyze the evolution of the climatic conditions of the area, then the dynamics of rice production, and finally, the impact of changes in climatic factors on rice production.

2.1. Changes in climatic conditions in the department of Bongouanou

This section highlights changes in climatic factors that may influence rice production. The factors studied for this report are rainfall, temperature and potential evapotranspiration. In addition, these factors were used to analyse changes in the drought index and the cropping calendar.

2.1.1. Rainfall trends marked by fluctuations

Rainfall data for the department from 1970 to 2024 show a slight upward trend with fluctuations in rainfall (Figure 3).

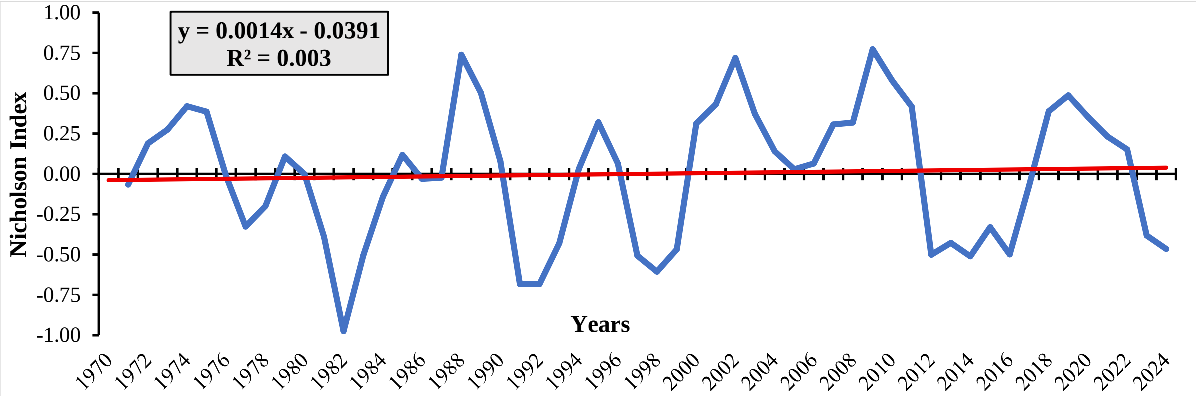


Figure 3 : Rainfall trend at the Moronou station from 1970 to 2024

Source : CRUTS_4.07 and Tera-climate, 2025

A strong alternation between years of excess and deficit rainfall, indicating instability in the rainfall pattern, is observed. The average rainfall from 1970 to 2024 is 1131 mm. Thus, two main sub-trends can be distinguished, one dry and the other wet. The first sub-trend, characterised by a dry phase, runs from 1970 to 1995, a series of 26 years of observation with an average of 1118.5 mm of water. Furthermore, of the 26 years in this trend, 13 years, or 50%, had a deficit, with 1983 having the largest deficit at 769.9 mm of water. There were 11 years with a surplus during this period and the other two were normal. The second sub-trend covers the period from 1996 to 2024, a series of 29 years with an interannual rainfall average of 1138.3 mm of water. Years with above-average rainfall are the most numerous (18) and account for 62.07% of the total, while the other 11 years have below-average rainfall and account for 37.93%. Furthermore, the equation on the right, expressed as $y = 0.0014x - 0.0391$, has a positive slope. This shows that rainfall in the Moronou region from 1970 to 2025 is on the rise, even if the slope remains low.

2.1.2. Rising temperature trends

The interannual average temperatures in the Moronou region reveal a rising temperature trend from 1970 to 2024 (Figure 4).

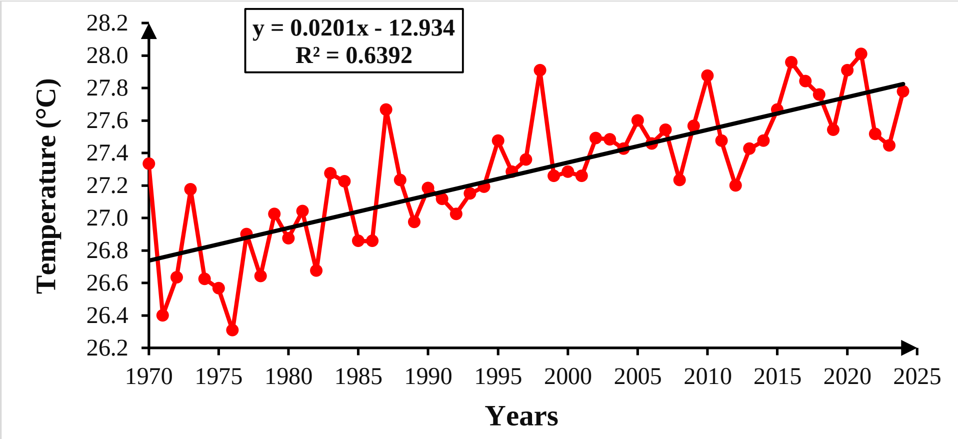


Figure 4 : Change in interannual average temperatures in the department of Bongouanou from 1970 to 2024

Source : CRUTS_4.07 and Tera-climate, 2025

During the period from 1970 to 2024, the average interannual temperature in the area is 27.3°C. Interannual temperatures show an upward trend, although marked by interannual fluctuations. Of the 55 years studied, only 4 years, or 07.27%, recorded a normal temperature or one equal to the series average. In contrast, 92.73% of the years in the series were characterised by temperature anomalies, with 47.27% below average and 45.46% above-average. From 2012 onwards, all years recorded temperatures above the series average, with the maximum observed in 2016 and 2021 (28°C). The trend line equation (y = 0.0201x – 12.934) and the estimated R^2 coefficient of 0.6392 confirm this upward trend in temperatures. This change in temperatures could have an impact on rice cultivation, which is very sensitive to thermal conditions.

2.1.3. Upward trend in interannual potential evapotranspiration (PET)

In the department of Bongouanou, from 1970 to 2024, interannual PET shows an upward trend with significant fluctuations (Figure 5). From 1970 to 2024, the average interannual potential evapotranspiration (PET) is estimated at 1130.2 mm. The interannual PET values during the study period fluctuate around this average, sometimes above and sometimes below it. In fact, there are 29 years with above-average PET values, representing 52.73% of the years in the series. On the other hand, 26 years, or 47.27%, have PET values below the series average. An alternation of years with above and below average PET values is observed from 1970 to 2015. However, since 2015, despite the alternations, all years have had above-average PET, with the maximum (1173.6 mm) observed in 2024. This trend reflects an increase in plant water demand in recent years in the department of Bongouanou. Such a dynamic could have repercussions on rice cultivation, particularly through water stress and disruption of the growing phases, thus leading to a decrease in production.

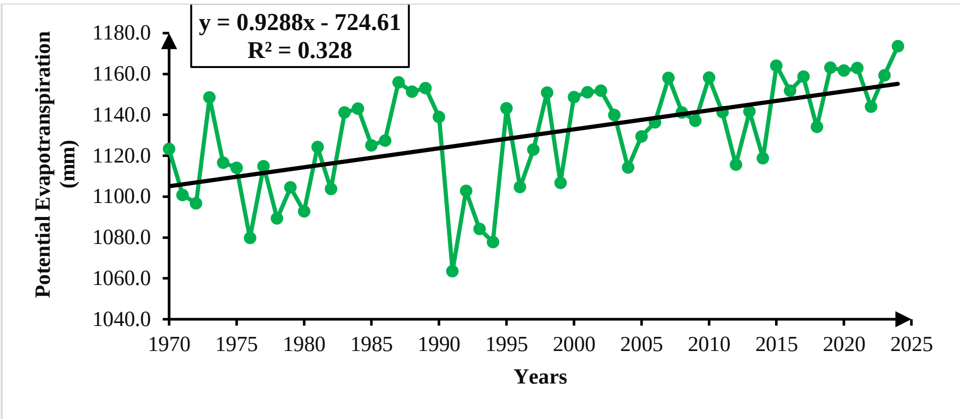


Figure 5 : Interannual changes in PET in the Bongouanou department from 1970 to 2024

Source : CRUTS_4.07 and Tera-climate, 2025

2.1.4. Gradually changing ecological conditions

In the department of Bongouanou, drought indices assessing the water balance show spatial dynamics over the years, marked by instability in the water balance from 1970 to 2024 (Table 2).

Table 2 : Evolution of the drought index in the department of Bongouanou

BONGOUANOU						
Period	**1970-1979**	**1980-1989**	**1990-1999**	**2000-2009**	**2010-2019**	**2020-2024**
Rainfall (mm)	1145.75	1138.35	1063.99	1190.88	1133.52	1102.48
PET (mm)	1108.85	1131.77	1109.60	1140.79	1144.72	1160.30
Drought Index	1.03	1.01	0.96	1.04	0.99	0.95
Characteristics Climatic or ecological	**Hyper-Humid**	**Hyper-Humid**	**Humid**	**Hyper-Humid**	**Humid**	**Humid**

Source : CRUTS_4.07 and Tera-climate, 2025

The department of Bongouanou initially experienced hyper-humid conditions during the decades 1970-1979 and 1980-1989, with respective indices of 1.03 and 1.01, despite the decline observed during the latter period. However, the area shifted to the humid category in the decade 1990-1999 with an index of 0.96, before temporarily returning to the hyper-humid category during the decade 2000-2009. Subsequently, the climate regime underwent a further change, stabilising in the humid category during the decade 2010-2019 with 0.99. Furthermore, this trend towards aridification is accentuated during the five-year period 2020-2024, when the drought index reaches its lowest value of 0.95. This confirms a lasting shift towards a humid ecological environment. The change in the drought index for the area can be explained by the significant decrease in rainfall and the constant increase in evaporation demand.

2.1.5. Changes in rice cultivation schedules

Controlling the cultivation schedule is a real challenge for farmers in the current context of deteriorating climatic conditions. In the department of Bongouanou, the rice cultivation schedule shows a trend from 1970 to 2024 (Figure 6).

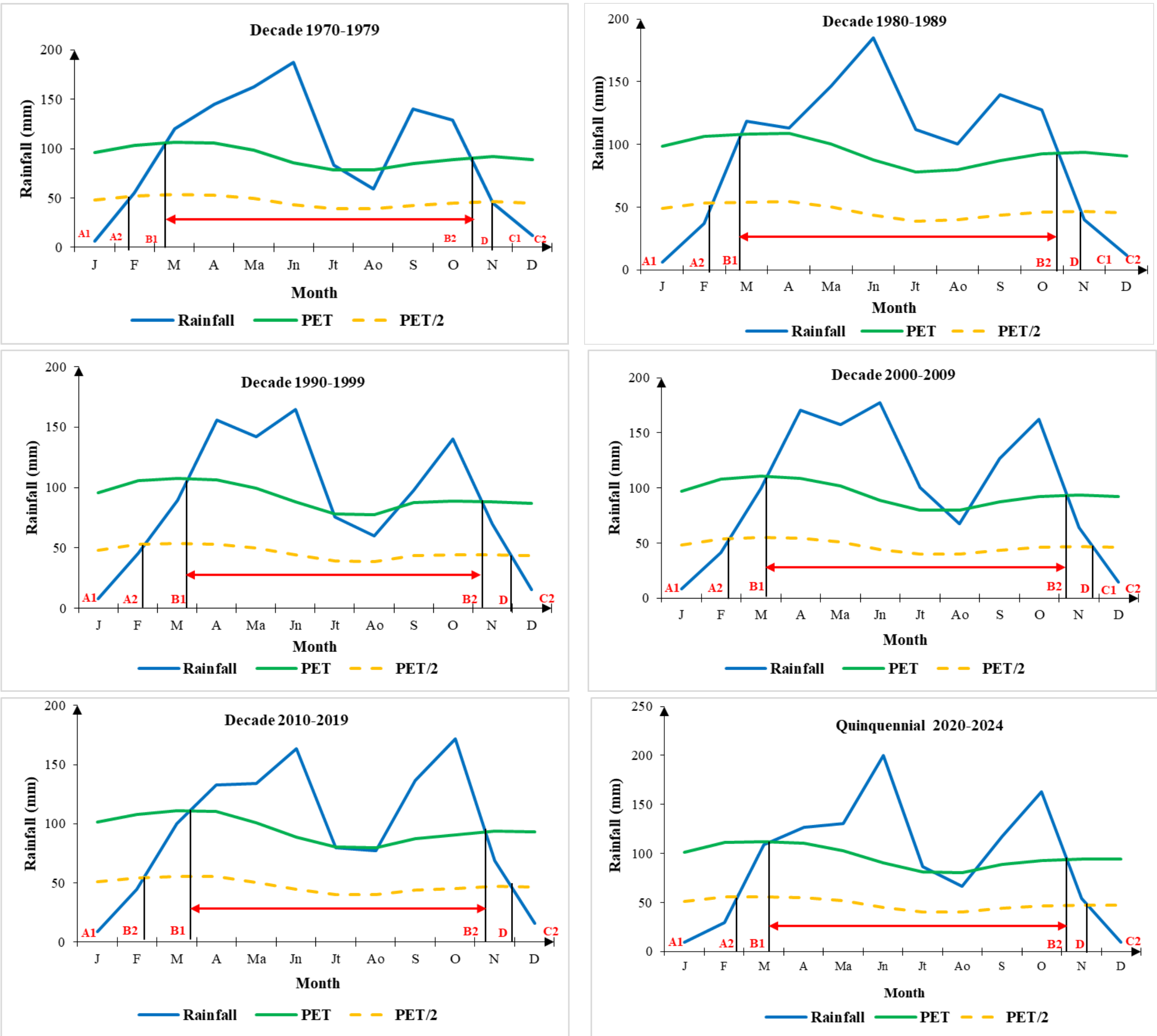


Figure 6 : Changes in rice growing seasons in the department of Bongouanou

Source : CRUTS_4.07 and Tera-climate, 2025

The cropping calendar in the department of Bongouanou has undergone a profound change. Sowing, which used to take place in early February to early March, now takes place from mid-February to mid-March (2020-2024), a shift of 15 days. This delay forces rice farmers to manage their calendars rigorously in order to avoid water stress at the end of the cycle. Rice farmers whose delay extends into April may experience significant difficulties during the heading and ripening period of their crop. Furthermore, phase B1-B2 (R>PET) corresponds to the rain season in the area, when water availability ensures that the rice's water requirements are met. The historically observed dip in rainfall in August marks the end of the first cycle and the beginning of the second cycle. Thus, according to the calendars, the first cycle currently (2020-2024) runs from mid-March to the end of July and lasts for an average of almost four months. However, the reduction in the duration of the first cycle and the irregularity of rainfall after August, which corresponds to the second cycle, mean that rice farmers in the area focus solely on the first cycle (March to July).

2.2. Dynamics of rice production and yields in the department of Bongouanou

In the department of Bongouanou, rice production and yields show a downward trend from 2015 to 2024 (Figure 7).

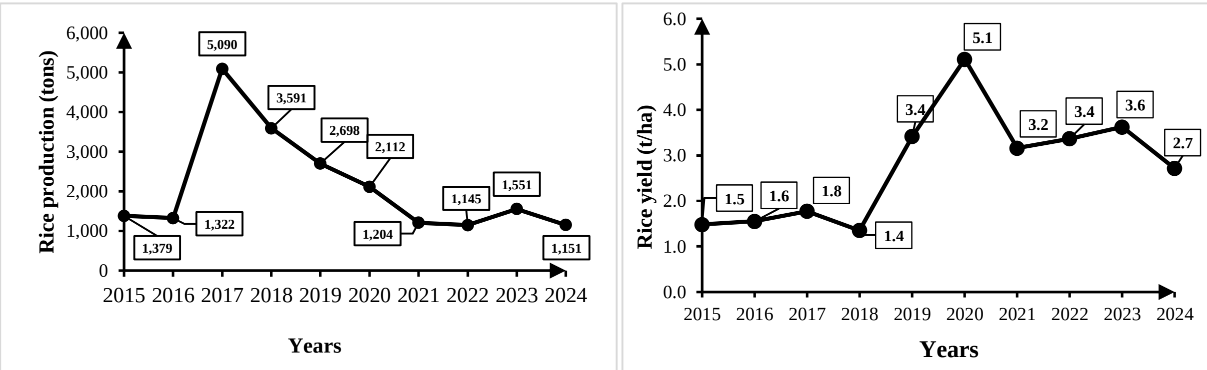


Figure 7 : Rice production and yield trends in the Bongouanou department from 2015 to 2024

Source : ADERIZ data, 2025

In the department of Bongouanou, rice production fell from 1379 tons in 2015 to 1,151 tons in 2024. After peaking in 2017 at 5090 tons, rice production fell to 2112 tons in 2020, before remaining at around 1000 tons until 2024, with 1151 tons of rice produced. Rice yields rose from 1.5 t/ha to 2.7 t/ha. Yields have varied over the years, with a peak of 5.1 t/ha recorded in 2020. The decline in rice production and yields in this area is partly due to the reduction in rice acreage caused by the abandonment of cultivation in favour of gold panning.

2.3. Impacts of changing climatic conditions on rice production

This section addresses the relationship between climatic factors and rice production and yields in the Bongouanou department.

2.3.1. Link between variations in rainfall and rice production

Rice cultivation in the department of Bongouanou is dominated by the rain-fed system. Rainfall is therefore a determining factor for this crop. Given that rice production in the area is experiencing an alarming decline, the two variables were correlated to identify the source of this decline in production (Figure 8).

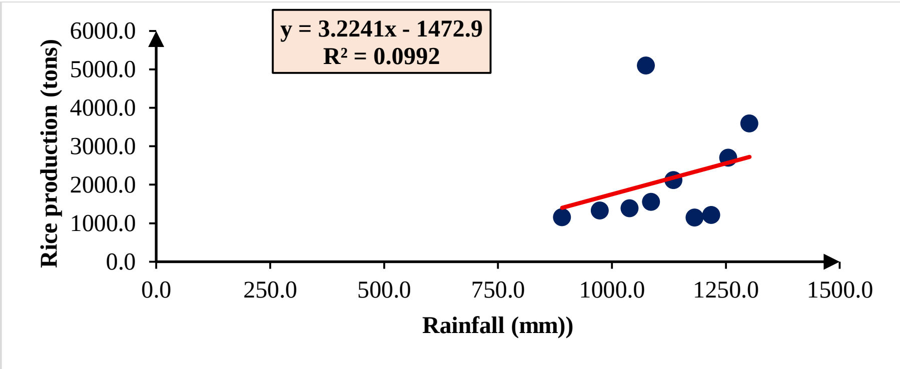


Figure 8 : Correlation test between annual rainfall levels and rice production in the department of Bongouanou

Source : CRUTS_4.07 and Tera-climate, 2025 and ADERIZ data, 2025

In this correlation, rice production is the explained variable and rainfall is the explanatory variable. The increasing trend and positive sign of the slope coefficient indicate that the two correlated variables are moving in the same direction. In other words, when rainfall increases, rice production also tends to increase, and vice versa. There is therefore a relationship between rice production and annual rainfall. Thus, with a significance level of 5% and a degree of freedom of 8, the r value read from Pearson's table is estimated at 0.6319. However, the calculated r value, which is 0.3149, is strictly lower than the r value read from the table. There is therefore a weakly significant correlation between average annual rainfall and rice production. According to the estimated r^2 of 0.0992, rainfall explains only about 0.92% of the variations in rice production in the department of Bongouanou. This result leads us to consider other explanatory variables.

2.3.2. Correlation between annual water regimes and rice production

The water regime and rice production were correlated (Figure 9).

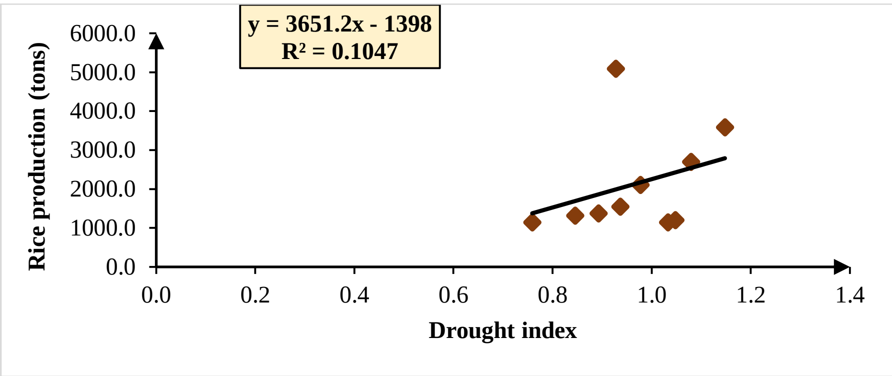


Figure 9 : Correlation test between water regime and rice production in the department of Bongouanou

Source : CRUTS_4.07 and Tera-climate, 2025 and ADERIZ data, 2025

The trend curve associated with the scatter plots is increasing with a positive slope. The two variables being compared therefore evolve in the same direction. In other words, when the drought index determining the water regime increases, production also increases, and vice versa. For a degree of freedom of 8 and a significance level of 5%, the critical threshold read from Pearson's table is 0.6319. The correlation coefficient r is estimated at 0.3235, a value strictly below the critical threshold. Thus, there is a correlation between the water regime and rice production, but it is statistically weak. The coefficient of determination r^2 (0.1047), which assesses the strength of the link, indicates that the annual water regime explains 10.47% of the variation in rice production in the department of Bongouanou.

2.3.3. Relationship between PET and rice yields

Evaporative demand from the atmosphere in the study area is gradually increasing. This upward trend could influence rice yields. The two variables were therefore correlated (Figure 10).

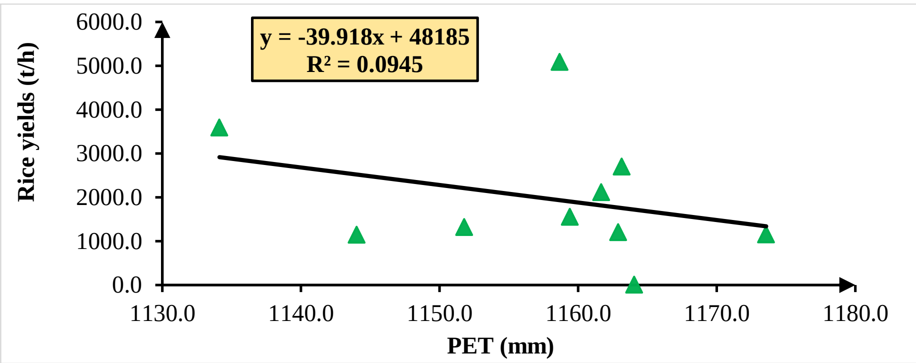


Figure 10 : Correlation test between PET and rice yield in the department of Bongouanou

Source : CRUTS_4.07 and Tera-climate, 2025 and ADERIZ data, 2025

In this correlation, rice yields are the explained variable and PET is the explanatory variable. The trend line associated with the scatter plot is upward sloping and its slope coefficient is negative. This indicates that the two correlated variables move in opposite directions. In other words, when PET increases, rice yields decrease and vice versa. There is therefore a relationship between PET and rice yield. Thus, for a 5% significance level and a degree of freedom of 8, the r read in Pearson's table is estimated at 0.6319. However, the calculated r (0.3074) is strictly lower than the r read. There is therefore a weakly significant correlation between annual rainfall averages and rice production. According to the estimated r2 of 0.0945, PET quantities explain only about 0.945% of the variations in rice yields in the department of Bongouanou.

2.3.4. Rice farmers' perceptions of the impact of climate variation on their rice crops

The rice farmers surveyed in the department of Bongouanou have different perceptions of the impact of climate variation on their crops (Table 4).

Table 4 : Rice farmers' perceptions of the impact of climate variation on rice crops

Perceptions of rice farmers	Occurrence	Frequency (%)
Decline in yields	53	42.06
Single-cycle cultivation	111	88.10
Crop destruction	52	41.27
Silting	03	2.38
Flooding during rice growth	16	12.70
Proliferation of insect and animal pests	09	7.14
Proliferation of weeds	07	5.56
Proliferation of rice diseases	13	10.32
Delayed sowing	113	89.68
Drought during rice growth	103	81.75

Source : Field surveys, Mariko Abdoulaye, 2025

In the study area, 126 rice farmers out of the 131 surveyed, or 96.18% of the total, say that changing climatic conditions affect their rice cultivation. The most common impacts are delayed sowing, single-cycle cultivation and drought during rice growth, with 89.68%, 88.10% and 81.75% respectively. The least reported impacts are sand encroachment and weed proliferation, with 2.38% and 5.56% respectively.

Discussion

The study shows that rainfall trends in the department of Bongouanou from 1970 to 2024 are on the rise and marked by highly variable fluctuations. These results contradict those obtained by P. Yao et *al*. (2022, p. 188), who report that rainfall in the department of Alépé has been declining for decades, with some years experiencing deficits. In addition, temperatures and potential evapotranspiration are also trending upwards in the department of Bongouanou. In Senegal, specifically in Lower Casamance, average temperatures have increased significantly (A. Badiane et *al*., 2022, p. 22). In northern Côte d'Ivoire, specifically in the Poro region, rising temperatures are likely to increase evapotranspiration (A. Touré, 2018, p. 81). Variations in these different climatic factors have affected the water regime and crop calendars in the department of Bongouanou. The water regime changed from pre-humid to humid, and the sowing period was extended by 15 days, thereby shortening the crop cycle. These results are similar to those of P. Yao et *al*., (2022, p. 183). They state that in the department of Alépé, the ecological environment changed from hyper-humid at the beginning of the series (1955-1964 and 1965-1974) to humid, with the rest of the decades and then the growing seasons undergoing changes over time. Similarly, B. Yao (2009, p. 14) notes a disruption in the duration and timing of the seasons, revealing a shortening of the rainy season and a lengthening of the dry season. Furthermore, in the study area, rice production has declined significantly, from 1379 tons in 2015 to 1151 tons in 2024. At the same time, rice yields have increased from 1.5 t/ha to 2.7 t/ha between 2015 and 2024, with significant interannual variation. This situation is similar to that in the department of Alépé, where rice yields have gradually declined (P. Yao et *al*., 2022, p. 185). Variations in various climatic factors affect rice production and yields in the Bongouanou area. These results are consistent with those of E. Ogouwalé (2006, p. 59) and T. Codjo (2013, p. 166), who showed that climatic conditions detrimental to agricultural production have an impact on farmers involved in rain-fed agriculture. They lead to increased water and heat stress on plants and result in lower yields of major crops, including maize, cowpea, cassava, sweet potato and rice. Furthermore, in the department of Bongouanou, rice farmers have different perceptions of the impact of climate variability on their crops. The most common perceptions are delayed sowing (89.68%), single-cycle cultivation (88.10%) and drought during rice growth (81.75%). These results corroborate those of A. Badiane et *al*., (2022, p. 11), who attest that rice farmers in Lower Casamance have a good understanding of the climate and its variability. Their survey reveals that the disruption of agricultural calendars (33.30%), declining yields (31.90%), the loss of 22.70% of rice-growing land, and the early drying up of valleys (36%) are the main impacts of climate deterioration on rice farming, according to rice farmers' perceptions.

Conclusion

This study reports on the impact of climate extremes on rice production in the department of Bongouanou. The results revealed that rainfall in the area from 1970 to 2024 is on the rise, with an interannual average of 1131 mm of water. However, the value of the slope coefficient ($y = 0.0014x - 0.0391$) and that of R^2 (0.003) indicate that the increase remains slight. During the same period, temperatures and potential evapotranspiration also rose, alternating between above and below the series average. Temperatures rose by 0.5°C, from 27.3°C in 1970 to 27.8°C in 2024. Evapotranspiration during this period rose from 1123.3 mm to 1173.6 mm, an increase of 50.3°C. The variation in these different climatic factors has affected the water regime of the area as well as crop calendars. The department of Bongouanou, initially characterised by a hyper-humid regime, found itself in the humid category during the last five-year period. The sowing date has also changed over the years (from early February to early March to mid-February to mid-March), with an extension of 15 days due to delays in rainfall. Production has declined from 1379 tons in 2015 to 1151 tons in 2024. Rice yields have increased from 1.5 t/ha to 2.7 t/ha between 2015 and 2024, with significant interannual variation. Variations in various climatic factors affect rice production and yields. Rainfall and the department's water regime account for 9.92% and 10.47% of the variation in rice production, respectively. Variations in rice yields are explained by 9.45% by PET. The links between current climatic conditions and rice production remain statistically weak. Thus, although local climatic factors do influence rice production, they are not the most decisive factors in rice production in the area. There are therefore other factors that explain the variation in rice production in the department of Bongouanou. In the study area, 96.18% of rice farmers say that climate variability influences rice cultivation. Their perceptions of the impacts of climate variation on rice cultivation are delayed sowing (89.68%), single-cycle cultivation (88.10%) and drought during rice growth (81.75%).

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