



Updating Seasonal Limits and Their Implications for Water Resource Management in the Poro and Tchologo Regions (Côte d'Ivoire)

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Abstract: This study aims to determine the duration of rainy and dry periods in the Poro and Tchologo regions of Côte d'Ivoire with a view to better planning agropastoral activities. The data used are monthly temperatures and precipitation from 1981 to 2020 from CHIRPS and NASA POWER satellite stations. The methodology consists of conducting a statistical study of precipitation and temperatures, then drawing up the hydrological balance using the Thornthwaite approach to determine potential evapotranspiration (PET) and arriving at the water balance. Finally, the pre-humid, humid and post-humid periods were delineated using the Franquin method. The results reveal that precipitation and temperatures vary from month to month. The highest temperatures are recorded from February to May. They are lower from July to September and from December to January. Precipitation reaches its peak in August and declines sharply in December. At the end of this study, it is noted that the dry season extends from October to April, or 7 months, while the rainy season covers the period from May to September, or 5 months. Since the dry season is long, resilience measures are necessary.

Keywords: Seasonal variability, dry season, rainy season, climate change, water resources, Poro, Tchologo.

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1. Introduction

The seasonal climate variability observed in Côte d'Ivoire since the 1960s and 1970s, as in other West and Central African countries, remains a reality today. Characterized by an alternation between wet and dry periods (Soro et al., 2014), this variability is manifested in particular by a decrease in annual precipitation and changes in rainfall patterns (Brou et al., 2005; Kouassi et al., 2008). In northern Côte d'Ivoire, dry periods are accompanied by a significant reduction in water sources, such as streams, dams, rivers, and wells, which limits the exploitable agricultural areas and restricts water availability for local communities (Boko et al., 2016). These changes have profound repercussions on the living conditions and economic activities of the region. Months with unexpected rains, prolonged dry seasons, and shorter rainy seasons put the regions in a climatic chaos to the point where it is difficult to properly carry out agropastoral activities. Mastering seasonality would allow for better planning of agricultural and pastoral activities and consequently an improvement in the living

conditions of the populations, especially since these activities are the main ones in the Poro and Tchologo regions.

2. Materials and Methods

2.1 Data and Materials

This work used monthly precipitation data in millimeters and ground temperature data in degrees Celsius. The data range extends from 1981 to 2020. They were downloaded in CSV format, making them easy to manipulate using Excel software.

These data come from satellite stations (CHIRPS version 2.0 for precipitation and NASA POWER for temperatures), available at <http://iridl.ldeo.columbia.edu/> and POWER | Data Access Viewer ([nasa.gov](https://power.larc.nasa.gov/)), respectively.

CHIRPS precipitation data (Climate Hazards Center InfraRed Precipitation with Station Data) are produced by the Climate Hazards Group (CHG) at the University of California, Santa Barbara (USA). Since the temperature data available on the



website <http://iridl.ldeo.columbia.edu/> only cover the period from 2000 to 2007, it was necessary to use another reliable site for downloading temperature data covering the same period as the precipitation. Also, in situ data from 2002 to 2012 for the study area are unavailable. Indeed, due to the political and military crisis that Côte d'Ivoire experienced, no observations were made at weather stations in the Central, Northern and Western regions of the country during the period from 2002 to 2012.

2.2 Methods

2.2.1 Calculation of Mean Precipitation and Temperatures, as well as Normal Precipitation

Mean monthly precipitation and temperatures were calculated over the study period (1981–2020) and plotted on a single graph. Normal precipitation, corresponding to the average precipitation recorded over the reference period, was also calculated and plotted on the same graph for the departments of Korhogo and Ferkessédougou.

2.2.2 Franquin Method

The Franquin method (1969) is an agroclimatological technique used to define pre-humid, humid, and post-humid periods in

tropical and subtropical regions by comparing precipitation and potential evapotranspiration.

It graphically combines the climatic parameters of precipitation, PET, and ½ PET. Calculation of PET

Potential evapotranspiration was calculated for each month using Thornthwaite's (1948) equation, where $PET = 16 \times (10t / I)^\alpha \times F(\lambda)$

PET: monthly potential evapotranspiration (mm)

t: monthly mean temperature in degrees Celsius

α : complex function of the thermal index ($\alpha = 6.75 \cdot 10^{-7} \cdot I^3 - 7.71 \cdot 10^{-5} \cdot I^2 + 1.79 \cdot 10^{-2} \cdot I + 0.49239$)

The PET for the different months was compared to the monthly precipitation.

I: Annual thermal index; it corresponds to the sum of the twelve monthly thermal indices (i) which is obtained by the formula of the equation: $i = (t / 5)^{1.514}$

F (λ) = Correction factor which is a function of the latitude of the place considered.

3. Results

Extension of seasons

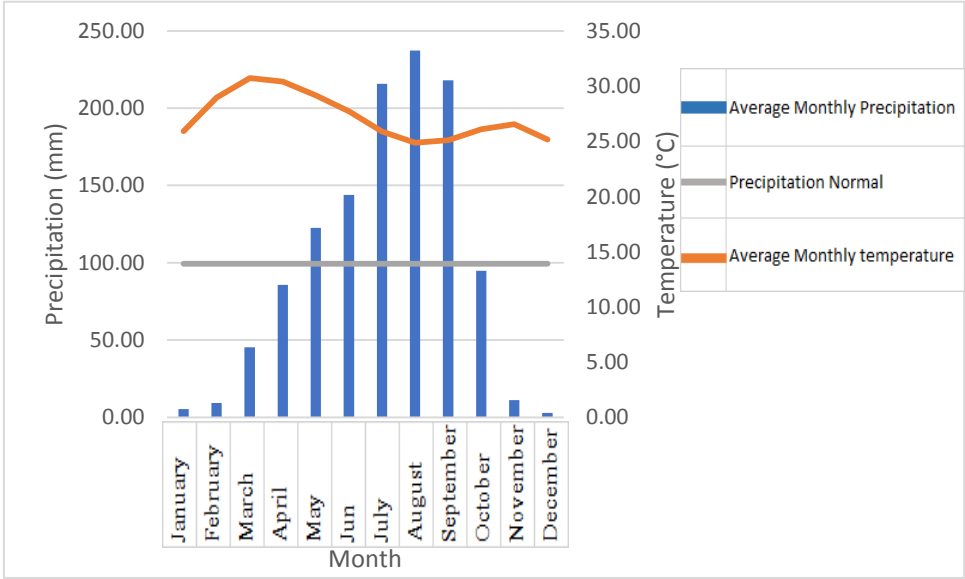


Figure 1: Ombrothermal and normal precipitation diagram Korhogo 1981-2020

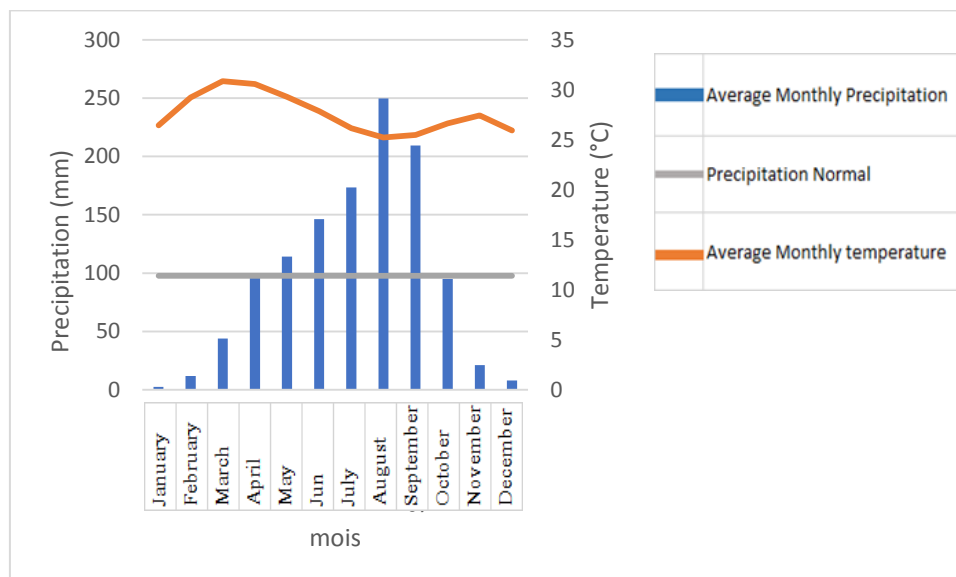


Figure 2: Ombrothermal and normal precipitation diagram for Ferkessédougou, 1981–2020

In the Korhogo department (Figure 1), from November to March, precipitation is low (50 mm), with values close to 0 mm for most months (November to February).

The months of April and October have values close to normal (99.28 mm) but still below it. The months of May to September record above-normal precipitation, but July, August, and September have the highest values, with a peak of 237.36 mm observed in August.

Temperatures remain generally high throughout the year, fluctuating between 25 and 30°C. They gradually increase from January to reach a peak in March (30.73°C). From April to June, a slight decrease in temperatures is observed. From July to September, temperatures remain relatively stable, with a slight decrease compared to the beginning of the year, reflecting the

moderating effect of heavy rainfall. From October to December, temperatures rise again after the end of the rainy season.

The trends observed in Ferkessédougou (Figure 2) are very similar to those in Korhogo, but with slight differences in temperature levels.

When normal precipitation is used as the threshold, two broad periods are identified:

Periods with below-normal monthly precipitation and periods with above-normal precipitation. The months with below-normal precipitation correspond to the dry months of the study period, and the months with above-normal precipitation correspond to the rainy months of the study period. Thus, in the departments of Korhogo and Ferkessédougou, the dry season lasts seven months, extending from October to April, and the rainy season lasts five months, extending from May to September.

Méthode de Franquin

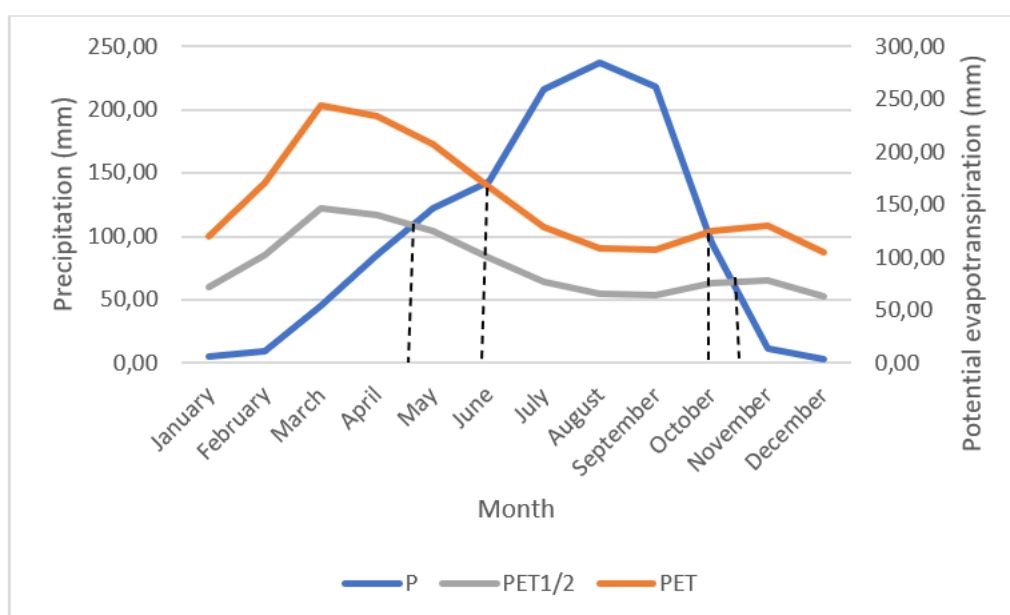


Figure 3: PET, ½ PET and rainfall in Korhogo from 1981-2020

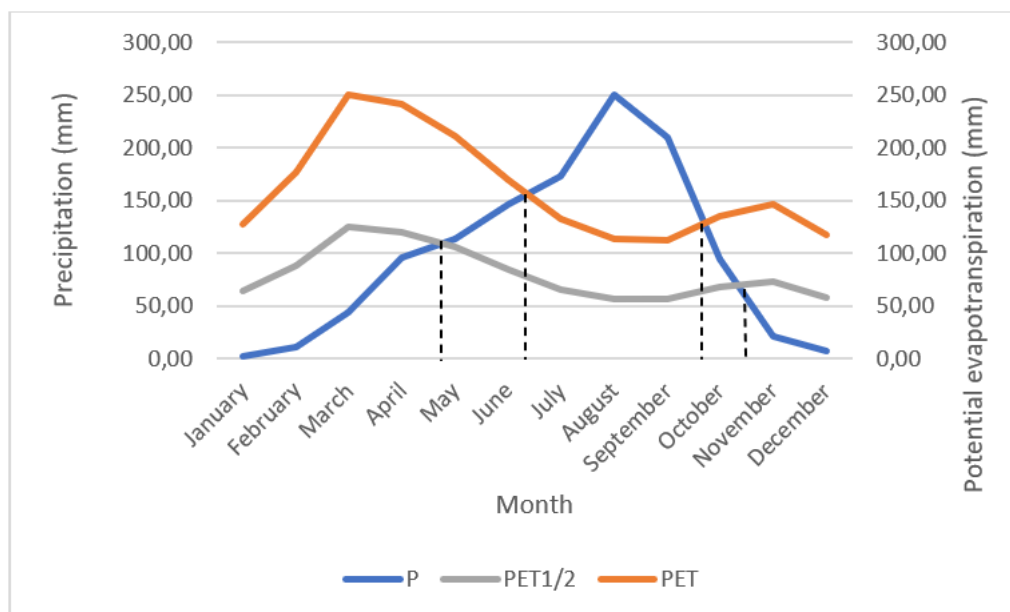


Figure 4: PET, ½ PET, and rainfall in Ferkessédougou from 1981 to 2020

In Korhogo and Ferkessédougou, vertical dotted line analysis identifies a pre-humid period, extending from mid-April to mid-June, a wet period from mid-June to mid-September, and a post-humid period from mid-September to mid-October.

It divides the rainy season into three phases based on the relationship between average monthly precipitation and potential evapotranspiration (PET):

- the pre-humid period: precipitation is between PET and PET/2. It is conducive to preparatory agricultural work (field clearing, sowing, etc.) and extends in Korhogo from mid-April to June;
- the wet period: precipitation is above PET, favoring maximum agricultural activity, extending from mid-June to mid-September in Korhogo;
- the post-humid period: rainfall decreases under PET and PET /2, marking the end of rainfed crops, from mid-September to mid-October in Korhogo (Figure 3).

In Ferkessédougou (Figure 4), the pre-humid period extends from mid-April to mid-June, the wet period is the same as that of Korhogo, which extends from mid-June to mid-September, and the post-humid period runs from mid-September to mid-October.

4 Discussion

Calculating precipitation, average temperatures, and precipitation normals for the period 1981 to 2020 made it possible to determine the monthly extent of dry and rainy periods in the departments of Korhogo and Ferkessédougou. These departments experience a long, seven-month dry season from October to April and a shorter, five-month rainy season from May to September. Indeed, northern Côte d'Ivoire has a Sudanese-type tropical climate characterized by a relatively longer dry season than the rainy season. This work is consistent with that of Kouadio (2004), who demonstrated seven dry months and five rainy months in northern Côte d'Ivoire; however, the length of the months is different. Kouadio's work reveals a dry season extending from November to May and a rainy season extending from June to October. This difference could be

explained by the length of the study period, or by a new definition of dry and rainy boundaries in light of climate change.

Eldin (1971) estimates that the dry season in the northern part of Côte d'Ivoire generally extends over six months. However, the emergence of a more pronounced dry season since the 1980s, observed by local populations (Boko et al., 2016), could explain the lengthening of the dry period in our results.

Franquin's (1969) method was used to determine favorable periods for preparatory agricultural work (field clearing, sowing, etc.), from mid-April to June. The favorable period for rainfed agriculture is from mid-June to mid-September, and the period for the end of rainfed agricultural activities is from mid-September to mid-October.

The dry season is not synonymous with an absolute absence of rain. However, this is a period when rainfall is irregular and generally low. Under these conditions, rain-fed agriculture cannot be practiced properly.

For pastoralists, the dry season has direct implications for the availability of pastures and watering holes, which are essential for livestock. The scarcity of water resources and the degradation of pastures during this period pose major challenges for pastoralists.

Under such conditions, it is imperative to use irrigation to maintain agricultural productivity and to develop hydraulic infrastructure such as boreholes and reservoirs to ensure water availability during this period.

Conclusion

This study shows that the dry season in the Tchologo and Poro regions now extends from October to April, i.e., seven months, and the rainy season is shortened to five months, from May to September. Franquin's method identified the period from mid-April to mid-June as the ideal time for agricultural preparation work. The period from mid-June to mid-September as the favorable period for intensive rain-fed agriculture and the period from mid-September to mid-October as the period of cessation of rain-fed agricultural

activities. A good development of agro-pastoral activities in these departments requires the use of appropriate techniques for mobilizing, managing, and distributing water resources.

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