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INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI: 10.21474/IJAR01/19982
DOI URL: http://dx.doi.org/10.21474/IJAR01/19982

ISSN NO. 2320-5407

RESEARCH ARTICLE

RAINFALL VARIABILITY IN THE PLATEAU REGION OF TOGO

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Manuscript Info

Manuscript History
Received: 25 September 2024
Final Accepted: 27 October 2024
Published: November 2024

Key words:-
Rainfall Variability, Plateau Region, Togo

Abstract

The Plateau region of Togo is classified under the Guinean tropical climate based on its latitude. Therefore, it should experience two rainy seasons and two dry seasons. However, a rainfall study of the stations in this region reveals a distinct characteristic compared to other stations in southern Togo. The question arises as to whether the evolving rainfall patterns in the region align with the previous classification. The aim of this study is to identify factors for a new categorization of rainfall amounts in the Plateau region of Togo. The data used for the study include rainfall amounts from the Atakpamé and Kouma-Konda stations to examine the evolution of rainfall over time and track the dynamics of the seasons. The rainfall data from the Tabligbo and Niamtougou stations are used for comparison. The construction of Gaussen diagrams is the primary method employed to monitor the distribution of rainy and dry seasons over time. The results indicate that the four seasons (two rainy and two dry) are gradually being replaced by two seasons (one rainy and one dry). Thus, the Guinean tropical climate shows a trend of shifting toward a Sudanian tropical climate in the Plateau region of Togo.

Introduction:-

Rainfall, uneven and often insufficient across much of the country, concentrates agricultural activities in the southern and southwestern regions, where conditions are more favorable (Bielders et al., 2006).

Crucial to crop development, rainfall influences both the selection of suitable varieties and the crops' response to fertilizer application. In a context where water is a limiting factor, analyzing agricultural risks inevitably involves a detailed study of rainfall variability, which not only determines the plants' water requirements but also affects the efficiency of agricultural inputs (Bielders et al., 2006).

Rainfall variability, defined as fluctuations in the spatial and temporal distribution of precipitation, can manifest as changes in intensity, duration, or frequency. These fluctuations have significant implications, particularly in tropical regions where agriculture largely depends on rainfall. For instance, in West Africa, marked alternations between dry and wet years impact agricultural yields, especially for crops like millet and maize, while exacerbating food insecurity and soil degradation (Nsegbé, 2023).

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Tools such as the Standardized Precipitation Index (SPI) allow for tracking long-term rainfall trends. A study conducted in the Tambacounda region of Senegal, for example, reveals a gradual decline in precipitation since the 1960s, confirming a similar trend in other Sahelian regions (Sambou, 2023).

This variability is further intensified by climate change, which increases the frequency of extreme events. This context calls for adaptation strategies, particularly through the development of drought-resistant varieties, improved water resource management, and the establishment of climate prediction systems (Sambou, 2023).

Togo is divided into two distinct climatic regions:

- The southern part, located between 6° and 8°N, experiences a Guinean tropical climate, characterized by two rainy seasons and two dry seasons.
- In the northern part, between 8°N and 11°N, a Sudanian tropical climate prevails, dominated by a long dry season and a long rainy season (Edjamé, 1994; 4th National Communication on Climate Change, Togo, 2022; Atlas of Togo, 1981).

A study focused on the climate of West Africa leads to similar conclusions (Janicot & Fontaine, 1993). The Gaussen diagrams constructed for the stations in this region should therefore show four seasons: two rainy and two dry. Map 1 presents the location of the Atakpamé and Kouma-Konda stations, which are the focus of this article.

The construction of ombro-thermal diagrams for the Atakpamé station did not yield the expected results.
This raises the research question: **Is the climatic classification of the Plateau region from the 1980s still relevant today?**

This question is significant as it challenges the previous climatic assumptions and necessitates an evaluation of current precipitation patterns and seasonal trends. Considering the observed climatic shifts and the possible influence of climate change on rainfall distributions, it is crucial to revisit and update the climate classification for this region. The comparison with other regions and stations, such as Kouma-Konda, could further elucidate whether the climatic characteristics in the Plateau region have evolved, supporting or challenging earlier classifications.

The objective is to identify elements for a new categorization of rainfall amounts in the Plateau region of Togo.

Methodology:-

Data Collection and Processing

The data used in this study includes monthly rainfall measurements from the Atakpamé, Kouma-Konda, and Tabligbo stations, spanning the period from 1961 to 2020, to analyze trends over time and track seasonal dynamics. For the Niamtougou station, data covers the period from 1981 to 2020. Temperature data for the same period were also collected.

Annual totals, decade-based monthly rainfall averages, and decade-based monthly temperature averages were calculated. These data were then used to construct Gaussen diagrams, following the P=2T rule (where P represents precipitation and T represents temperature). This methodology allows for a detailed analysis of the relationship between temperature and precipitation and provides insights into the temporal distribution of seasons in the Plateau region of Togo.

Results:-

Year-on-Year Evolution of Precipitation

The first step of the study is the analysis of the temporal evolution of annual rainfall data.

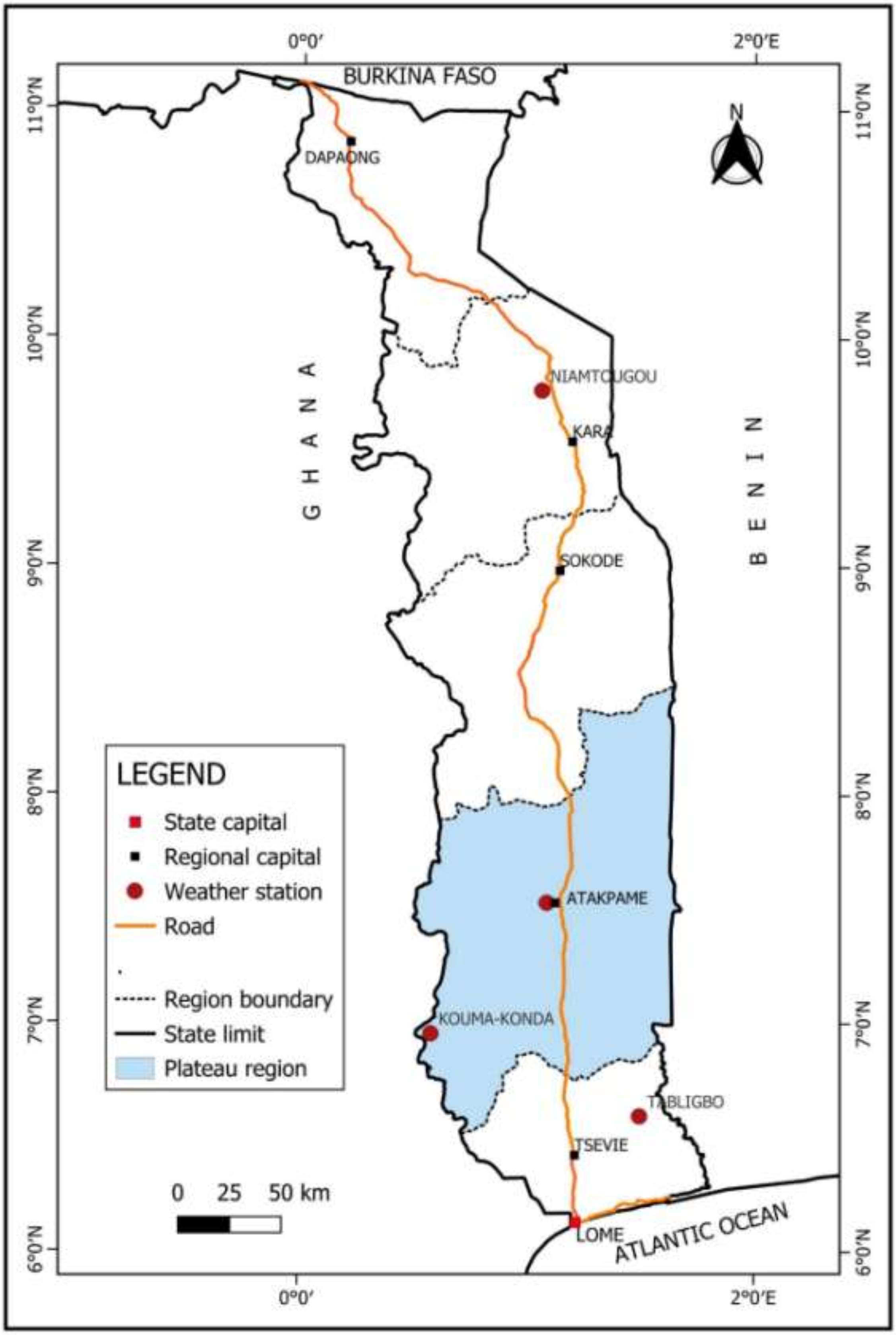

Figure 1:- Geographic Location of the Research Area.

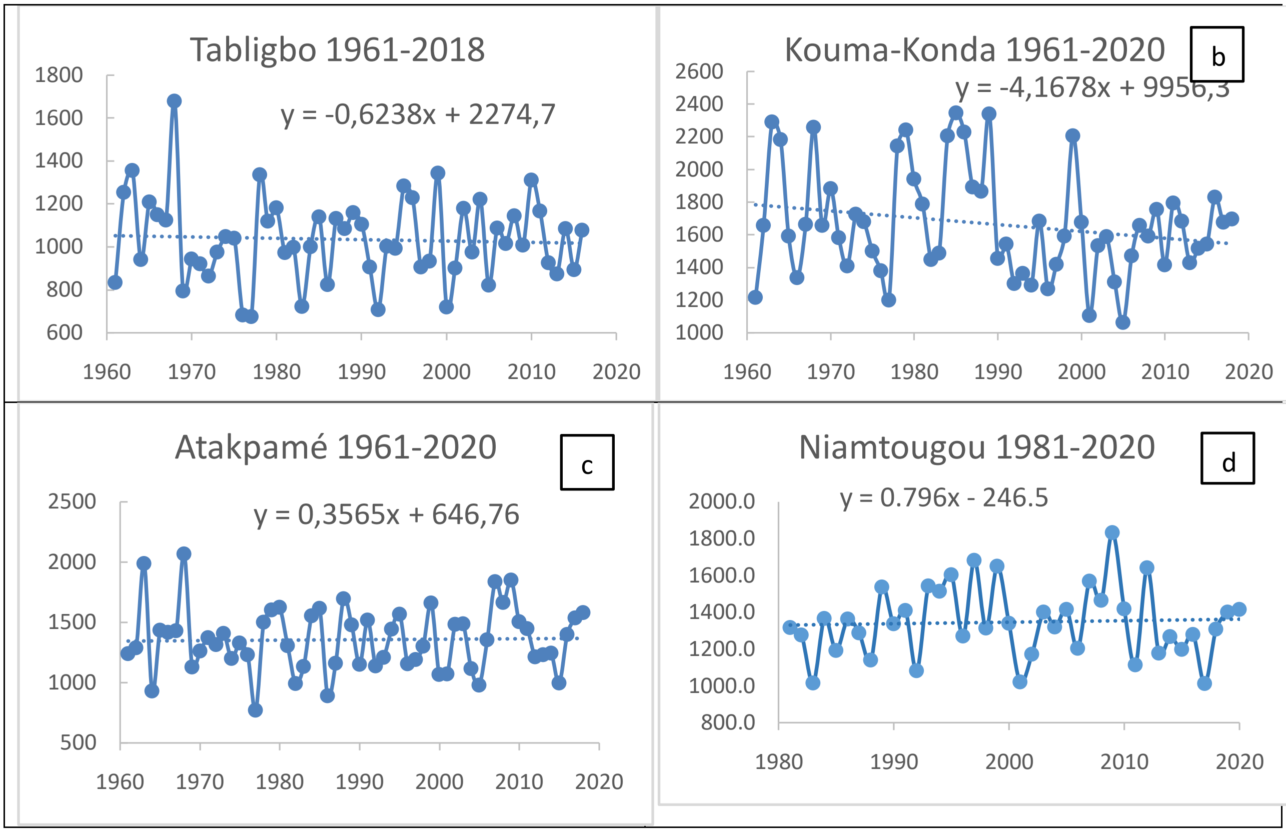

Figure 2:- Interannual Precipitation at the Study Stations.

The regression coefficients derived from linear trends reveal notable disparities in the precipitation evolution of the studied stations, highlighting a contrasted regional dynamic. In Tabligbo, a slight decrease of -0.6 mm is observed, while in Kouma-Konda, this decrease is significantly more pronounced at -4.16 mm, indicating an increased vulnerability of this area to precipitation deficits.

In contrast, the stations in Atakpamé and Niamtougou show opposite trends, with respective increases of 0.35 mm and 0.79 mm. This interregional contrast underscores the influence of local climatic particularities and microclimates on precipitation distribution.

A striking aspect is the contradictory evolution of the two stations located in the Plateaux region: Kouma-Konda registers a notable decrease, while Atakpamé shows a slight increase in precipitation. This difference suggests that local factors, such as topography or specific interactions between atmospheric dynamics and geographical characteristics, play a decisive role.

Furthermore, the similarity between the trend observed in Atakpamé and that of Niamtougou, despite belonging to two distinct climatic regions (soudano-guinean for Atakpamé and tropical sudanian for Niamtougou), illustrates the complexity of regional climatic influences. This invites further investigation into the underlying mechanisms, particularly considering the interactions between precipitation variability and large-scale climatic phenomena, such as monsoon dynamics or atmospheric circulation anomalies.

This finding calls for a differentiated management of water resources and adaptation of agricultural strategies, taking into account local particularities and future projections.

Variability of Monthly Precipitation on Ombro-Thermic Diagram

To track the evolution of the rainy seasons, Gaussen diagrams are created for the study stations by decade. Figure 3 presents the diagrams for the Atakpamé station.

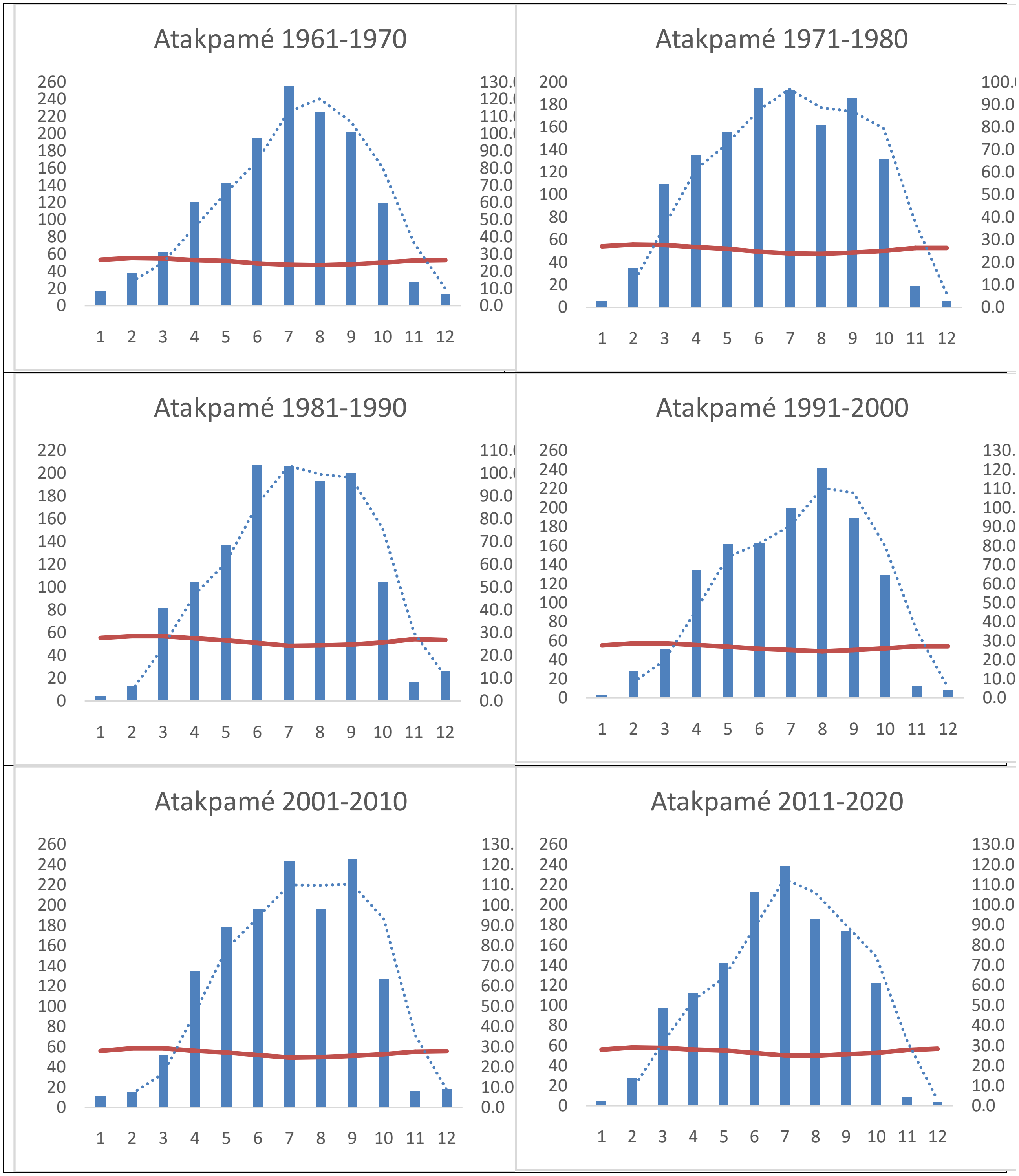

Figure 3:- Gaussen Diagrams for the Atakpamé Station by Decade.

The analysis of climate data highlights the presence of two distinct seasons at the Atakpamé station, with a dry season lasting 4 to 5 months. This observation diverges from classical descriptions that typically attribute four seasons to this region. This apparent simplification of the seasonal regime may reflect a recent evolution in local climatic characteristics or variations related to topographical and atmospheric factors influencing precipitation dynamics.

For the Kouma-Konda station, also located in the Plateaux region, the Gaussen ombro-thermal diagrams (shown in Figure 4) allow for a deeper analysis. The available climate data, covering the period from 1981 to 2020, provide a solid basis for assessing long-term trends. The evolution of precipitation and temperature over this period could explain the observed differences in seasonal distribution and offer insights into the potential impacts of climate change in this area.

These results underscore the necessity of considering local specificities when analyzing seasonal regimes, integrating robust tools such as climate diagrams, and comparing observations with historical averages to identify possible climatic shifts or transitions.

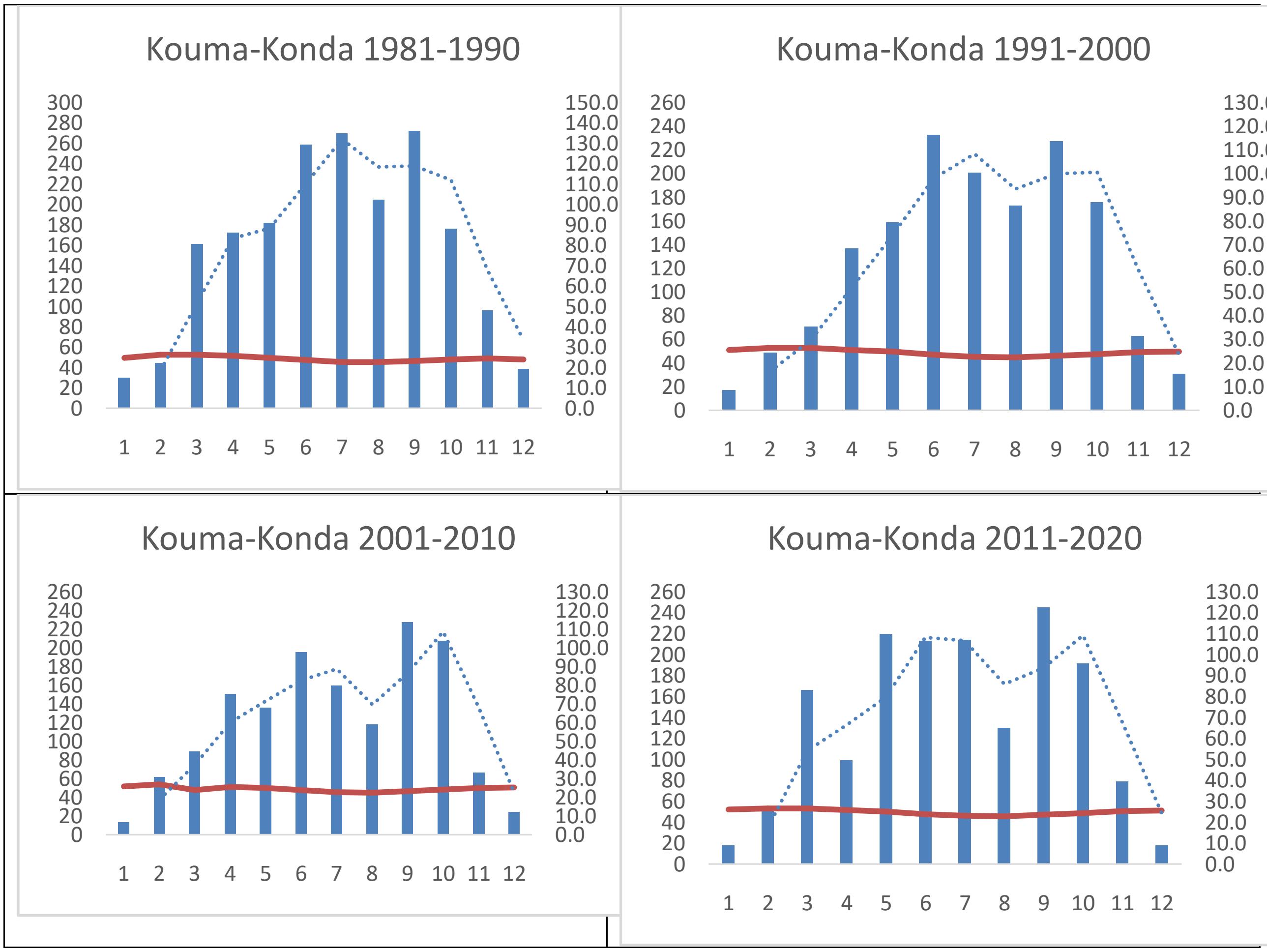

Figure 4:- Gaussen Diagrams for the Kouma-Konda Station by Decade.

The analysis of climate diagrams highlights significant differences between the studied stations while revealing common characteristics specific to the Guinean tropical climate zone. At Kouma-Konda, the four climatic seasons are distinctly discernible, confirming the alternation between two wet and two dry seasons. A notable feature of this station is the observed decrease in precipitation during August, often interpreted as a short second dry season within the year. This characteristic, well-documented in tropical regions, results from the rainfall pause associated with monsoon dynamics.

To deepen the comparison, the climate diagrams for the Tabligbo and Niamtougou stations were also examined. Tabligbo, located in the same climatic zone as Kouma-Konda and Atakpamé, should logically display similarities with these stations. However, discrepancies may arise due to local influences, such as topography, proximity to large water bodies, or specific microclimates. These factors play a key role in the distribution of precipitation and seasonal dynamics.

The data from Niamtougou, situated in a different climatic zone (Sudano-tropical), complement this comparative analysis. Although belonging to another climatic region, points of convergence with the Plateaux stations can be observed, particularly in seasonal cycles related to major atmospheric oscillations, such as the advance and retreat of the ITCZ (Intertropical Convergence Zone).

This analysis underscores the importance of studying not only regional climate averages but also local specificities. These nuances enhance the understanding of precipitation dynamics and help anticipate potential impacts on ecosystems and agricultural practices.

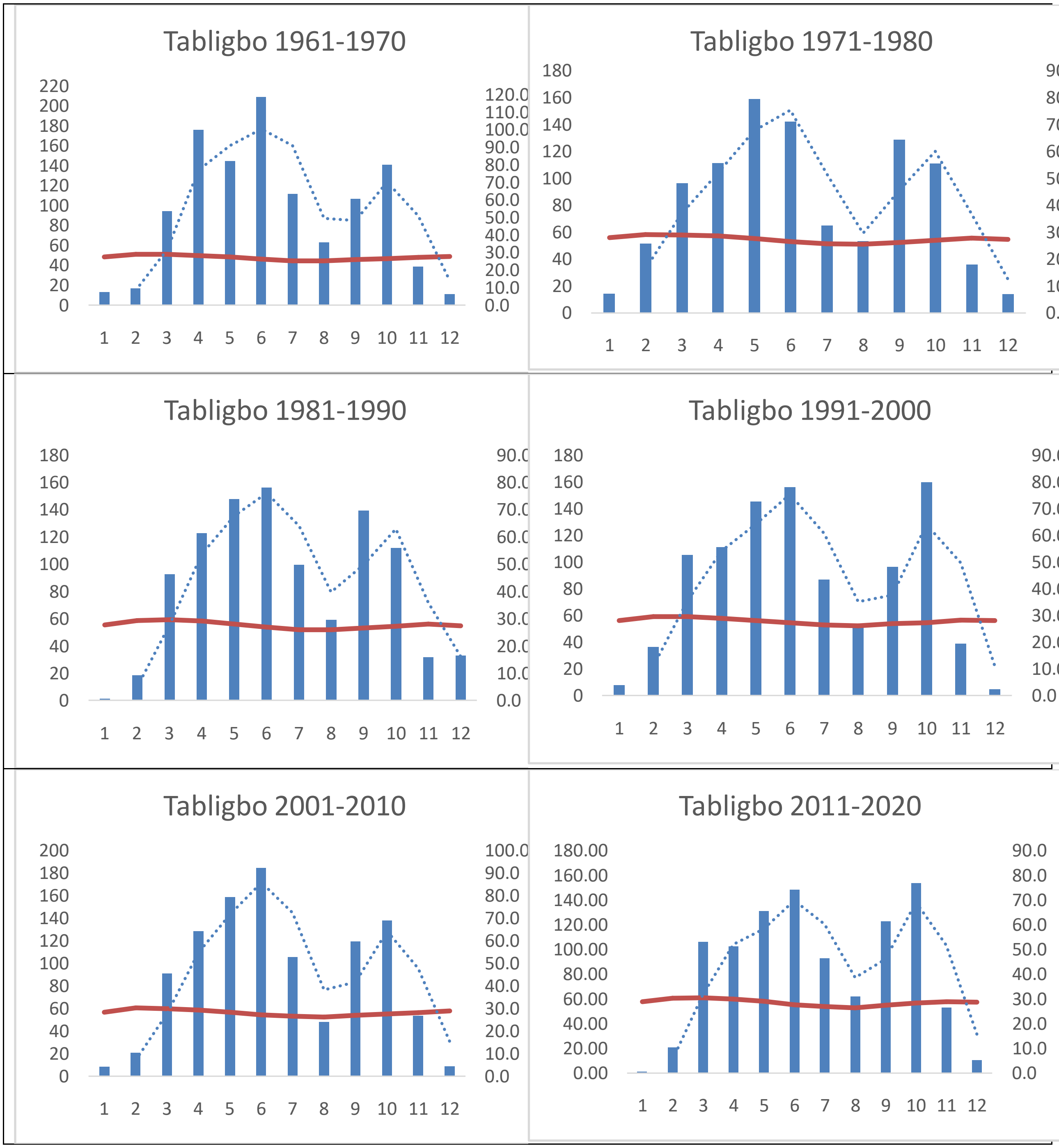

Figure 5:- Gaussen Diagrams for the Tabligbo Station by Decade.

The analysis of climate data from the Tabligbo station, as shown in Figure 5, highlights a clear distinction of the four typical climatic seasons of the Guinean tropical zone. This configuration is particularly marked by the emergence of a short dry season in August, visible on the precipitation histograms, where values are equal to or lower than the temperature curve. This phenomenon corresponds to the characteristic rainfall pause, often associated with variations in the dynamics of the African monsoon.

This short dry season emphasizes the seasonal regularity specific to Tabligbo, reinforcing the idea that this station shares the same fundamental climatic traits as other locations in the zone, such as Kouma-Konda or Atakpamé. Such a distinction is crucial for agricultural planning, as it directly influences crop choices and water resource management strategies. Indeed, a nuanced understanding of these seasonal cycles can optimize agricultural calendars and mitigate the impacts of climatic variations.

These observations are part of a broader analysis of regional precipitation regimes, highlighting both the similarities and local particularities of the studied stations.

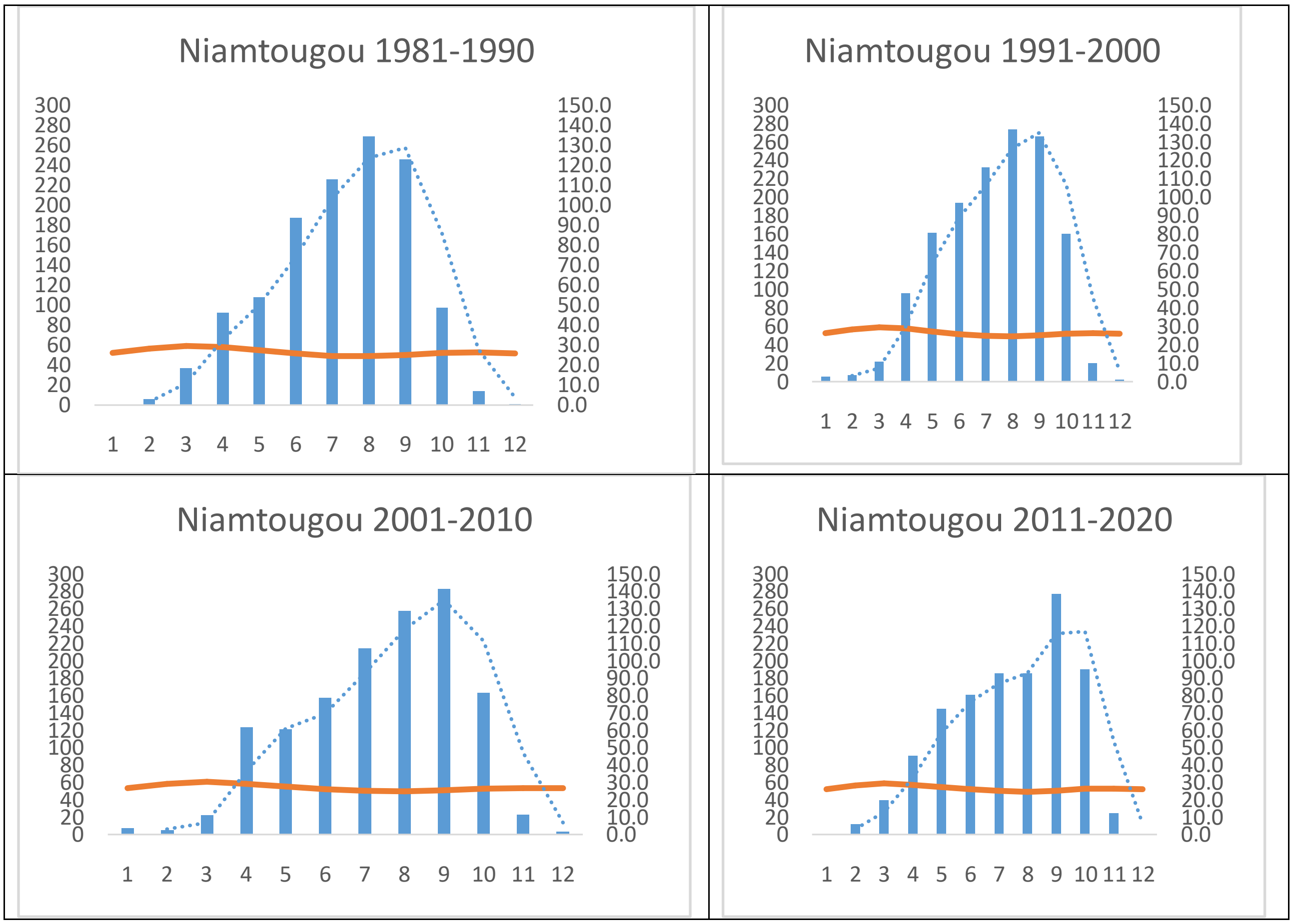

Figure 6:- Gaussen Diagrams for the Niamtougou Station by Decade.

The analysis of climate diagrams shows that the Niamtougou station is characterized by a long rainy season lasting seven months, followed by a five-month dry season, typical of the Sudano-tropical climate. Interestingly, the Kouma-Konda and Atakpamé stations, although located in the Plateaux region, exhibit Gaussen diagrams that are more similar to those of Niamtougou. This suggests a gradual shift from the Guinean tropical climate, characteristic of this region, toward a Sudano climate regime.

This phenomenon is particularly evident in the interpretation of the short dry season often described in the Guinean tropical climate. In the Plateaux, this period appears to correspond more to a simple decrease in precipitation intensity within the rainy season, without a significant interruption of rainfall. This nuance highlights the complexity of climatic transition in this region and reflects the increasing influence of Sudano factors on the precipitation regime.

These observations underscore the need to rethink climatic classifications in transitional areas such as the Plateaux of Togo. Such an approach would enhance the understanding of the impacts of this climatic transition on local ecosystems and agricultural practices, particularly regarding crop choices and water resource management.

Discussion:-

The questioning of the existence of a true short dry season in southern Togo, as raised by Edjame (2011), is based on solid climatic arguments. Contrary to the traditional idea of a marked interruption of rainfall between mid-July and the end of August, this period is characterized by specific weather conditions that do not meet the criteria for a true dry season.

During this time, temperatures are significantly cooler, sometimes reaching 17° to 18°C, which is exceptionally low for a tropical area. This cooling coincides with a reduction in sunlight, resulting in often overcast skies. Although precipitation is less abundant in volume, it does not completely cease. Instead, it manifests as light and persistent rains, reflecting the constant humidity of the atmosphere. These characteristics diverge from the typical conditions of a dry season, which is marked by a near-total absence of rainfall and high sunlight.

The terminology of "short dry season" for this period thus seems inadequate. It would be more appropriate to refer to it as an "atypical period" or "moderate rainfall anomaly," highlighting its transitory nature and distinctness from the classic regime of tropical seasons. The observed cooling could be attributed to incursions of cool air aloft or atmospheric disturbances, such as increased cloud cover related to variations in monsoon dynamics.

This distinction is not merely a matter of terminology; it has practical and scientific implications. For agriculture, for example, this period, although it presents less rainfall, can still support certain crops sensitive to excess water, while requiring adapted management due to reduced sunlight. In climatic terms, a better understanding of this phenomenon could refine regional forecasting models and enable more effective adaptation to local climatic conditions, especially in the context of climate change.

Thus, the debate around this period highlights the complexity of climatic dynamics in tropical zones, calling for more nuanced analysis and a revision of concepts to better reflect climatic reality and its implications.

Conclusion:-

The analysis of climate data from the Atakpamé and Kouma-Konda stations reveals a significant dynamic: the gradual transition from a four-season regime, typical of the Guinean tropical climate, to a two-season regime, characteristic of the Sudano tropical climate. This shift reflects a climatic transformation in the Plateaux region, illustrating changes in the seasonal distribution of precipitation and temperatures.

This observation calls for a thorough reflection on the factors underlying this transition. Several hypotheses can be considered. First, the role of global climate change must be assessed, particularly its impact on the regional dynamics of the Intertropical Convergence Zone (ITCZ) and the West African monsoon. Variations in rainfall regimes might reflect a local response to global changes, such as rising temperatures or the intensification of extreme weather events. Second, it is also necessary to evaluate the relevance of current climatic classifications. These may no longer accurately capture local specificities, especially in transitional areas like the Plateaux of Togo.

A detailed analysis of precipitation and temperature trends over longer periods, along with the integration of modern tools such as regional climate models and satellite data, would deepen this study. This would help determine whether the observed shift is the result of a natural climate variability process or if it is exacerbated by anthropogenic factors.

Finally, these potential climatic changes have significant implications for local populations, particularly in terms of agricultural management and water resource availability. A better understanding of these dynamics is essential to anticipate future impacts and develop resilient adaptation strategies. This work highlights the need for collaboration among climatologists, agronomists, and policymakers to effectively address these challenges.

Future perspectives stemming from this article include studying more stations in the Plateaux region, determining the start and end dates of the rainy season and their duration, and investigating humidity and potential evapotranspiration (ETP).

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