

Analysis of the Variability of Agrometeorological Characteristics in the Faranah Region (Guinea)

Magbini Tokpa Mamy^{1*}, Galakpaye Pivi², Piou Dobo Guilavogui¹

¹Department of Meteorology, University of N'Zérékoré, N'Zérékoré, Republic of Guinea

²Department of Meteorology, Climatology and Atmospheric Protection, Russian State Hydrometeorological University, Saint Petersburg, Russia

Email: *ouoseny@gmail.com, galakpayepivi@gmail.com, guilaopiou0@gmail.com

How to cite this paper: Mamy, M.T., Pivi, G. and Guilavogui, P.D. (2026) Analysis of the Variability of Agrometeorological Characteristics in the Faranah Region (Guinea). *Agricultural Sciences*, 17, 46-57. <https://doi.org/10.4236/as.2026.171004>

Received: December 25, 2025

Accepted: January 23, 2026

Published: January 26, 2026

Copyright © 2026 by author(s) and Scientific Research Publishing Inc. This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

<http://creativecommons.org/licenses/by/4.0/>



Open Access

Abstract

Current climate change trends are leading to the emergence of meteorological and climatic risks for agriculture. To better understand these risks, it is essential to analyse current trends in meteorological and agro-meteorological indicators. This study examines the variability of these indicators in the Faranah region in order to understand local climate dynamics and assess their implications for the agro-climatic system. The assessment of agroclimatic resources is based mainly on the sum of active temperatures (STA), Selyaninov's hydrothermal coefficient (GTK) and the standardised precipitation index (SPI). The study highlights annual and interannual variations and current trends in temperature, rainfall anomalies and agroclimatic indices. Three phases appear between 1994 and 2024: wet (1994-2000), dry (2001-2007) and unstable (2007-2024). The sum of active temperatures remains stable overall, except between 2001 and 2008. These dynamics reflect the impact of climate change, accentuated by human activity, and highlight the urgent need for agroclimatic adaptations.

Keywords

Agrometeorological Indicators, Climate Variability, Active Temperature Sum, Hydrothermal Coefficient, Drought Index

1. Introduction

Climate variability is one of the main challenges facing global agriculture in the 21st century [1]. Under the influence of climate change, fluctuations in precipitation, temperature and other meteorological parameters directly affect the availa-

bility of agroclimatic resources, crop productivity and food security [2]. In many tropical regions, where rain-fed agriculture dominates, this variability is particularly intense, making agroforestry and pastoral systems especially vulnerable to weather hazards [3].

The agroclimatic characteristics of a country or subnational region are mainly determined by the intra-annual distribution and interannual variations in precipitation and air temperature [4] [5]. However, climate is rarely considered a valuable natural resource for economic and social growth, as long as no serious events disrupt energy production, agricultural activities or threaten the health of the population.

Agriculture is generally the most important economic sector in developing countries, particularly in least developed countries and small island developing states. Agricultural practices and farm productivity depend to a large extent on rainfall and temperature. Agriculture and other sectors are therefore extremely vulnerable to climate change [6]. In the semi-arid and sub-humid areas of West Africa, rainfall is highly variable and irregular, which affects agricultural productivity. Agricultural activity has had to adapt to these climate risks by introducing irrigation techniques. However, very little land is irrigated. Consequently, any change in the current climate threatens agricultural productivity and the survival of many population groups in West Africa.

The Republic of Guinea is a country with significant agro-sylvopastoral potential. To exploit this potential, agricultural planning is required, which is impossible without a thorough understanding of the current climate, particularly rainfall variability and distribution [7]. Due to direct and long-term anthropogenic impacts on the natural environment, issues related to climate change and variability (temperature and rainfall) have long been the focus of attention for scientists and politicians around the world [8]. Issues related to climate change and variability have been studied for a long time, and the results show that the climate varies from one country to another, and sometimes even within the same country, due to the existence of several different ecosystems [9]. The most important issue, particularly for the Faranah region, as for other regions of the country, is to study climate change and variability at the local level so that policymakers can adapt to climate risks and take advantage of any positive effects that may result [10].

Rainfall is the most important climatic parameter in Guinea, both for the population and for ecosystems, and thus determines the different natural regions [11], [12]. As a result, the country's economy is mainly focused on activities that depend on the climate, including rainfall [13]. In a context of high vulnerability and limited capacity, a slight change in the nature of rainfall can have an immediate impact on vulnerable economic and social sectors whose activities depend on rainfall [14].

Knowledge of the variability of these parameters is very important for planning agricultural activities. Similarly, knowledge of agro-meteorological characteristics can be used to improve methods for forecasting agro-meteorological conditions

in the region. Thus, in this study, we will analyse and characterise the climatic variability of the agro-climatic parameters studied in the Faranah region between 1994 and 2024.

2. Materials and Methods

2.1. Knowledge of the Study Area

The Republic of Guinea has eight administrative regions, and this study focuses on the region of Faranah (**Figure 1**).

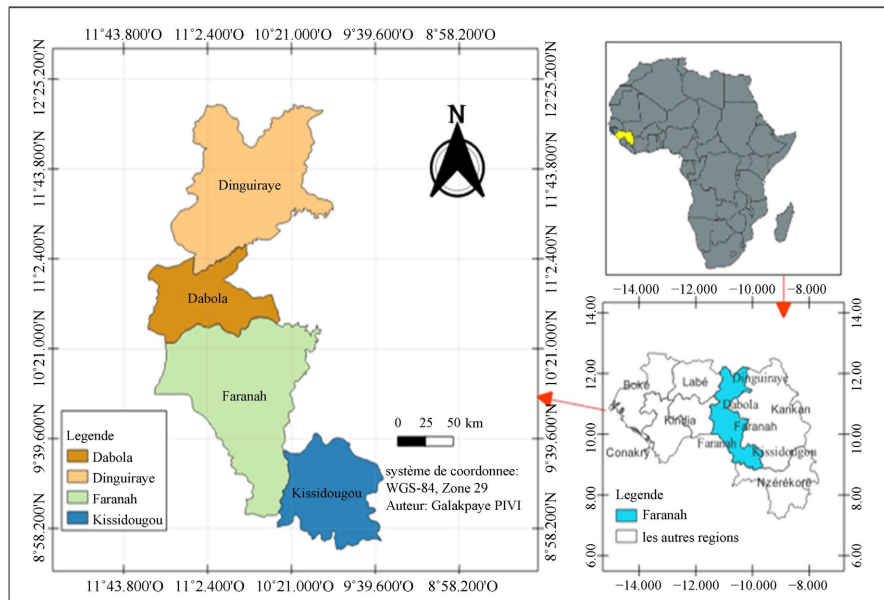


Figure 1. Map of the administrative region of Faranah (source: Galakpaye PIVI-2025).

The administrative region of Faranah is located in the centre of the country, between Fouta-Jallon, Forest Guinea and Upper Guinea. It is located between $8^{\circ}50'$ and 12° north latitude and $9^{\circ}15'$ and $11^{\circ}29'$ west longitude. It covers an area of 35.581 km^2 .

It is bordered to the east by the administrative region of Kankan, to the north by the Republic of Mali, to the west by the administrative regions of Mamou and Labé, to the south-west by the Republic of Sierra Leone and to the south by the administrative region of Nzérékoré (**Figure 1**).

The general climate is typical of the Sudano-Guinean type, with two alternating seasons: a rainy season and a dry season. Thanks to its geographical location between Fouta-Djallon, Upper Guinea and Forest Guinea, the region is influenced by three types of microclimates: tropical mountain or “Foutanian” climate, tropical sub-Saharan and sub-equatorial.

Average annual rainfall varies between 1,200 mm and 1,700 mm, reaching 2,000 to 2,500 mm in the south, on the border with the forest region. Temperatures are generally high, ranging on average between $+25^{\circ}\text{C}$ and $+30^{\circ}\text{C}$. Average relative humidity varies between 69% and 85%, and the prevailing winds are the Harmat-

tan and the monsoon.

The population of the Faranah region is mainly rural, and the functioning of economic systems (agriculture and livestock farming) is closely linked to weather and climate conditions.

2.2. Data Collection and Methods

The following meteorological data were used to conduct the research: air temperature characteristics and precipitation amounts for the Faranah region between 1994 and 2024. Data on air temperature, maximum and minimum temperatures, and average monthly and annual rainfall were obtained from NASA's MERRA-2 project website.

To determine the variability of agroclimatic parameters, daily rainfall data recorded between 1994 and 2024 by the Faranah region meteorological observatory were used. FORTRAN, Excel, Word and Grapher software were used to process the data and present the results. QGIS was used to edit the maps.

The following indicators were used to assess agroclimatic resources: the sum of active temperatures (SAT) of the air during the active growing season of agricultural crops; Selyaninov's hydrothermal coefficient (GTK) [15]; the Standardised Precipitation Index (SPI).

- ✓ STA is the sum of daily average air temperatures above +10°C during the active growing season (May to October). GTK is calculated using formula (1).

$$GTK = \frac{\sum P}{0.1SAT} \quad (1)$$

where $\sum P$ is the sum of precipitation during the active growing season (mm).

The classification of humidification zones based on Selyaninov's hydrothermal coefficient (GTK) consists of several categories:

- Regions with a GTK between 1.6 and 1.3 are considered humid;
 - Regions with a GTK between 1.3 and 1.0 are considered slightly arid;
 - Regions with a GTK between 1.0 and 0.7 are classified as arid;
 - Regions with a GTK between 0.7 and 0.4 indicate very arid conditions;
 - Regions with a GTK below 0.4 are classified as dry.
- ✓ The Standardised Precipitation Index (SPI),

$$SPI = \frac{X_i - \bar{X}}{S} \quad (2)$$

where X_i is the monthly rainfall value, \bar{X} is the average rainfall, S is the standard deviation of rainfall over the last 30 years.

The characteristics of the humidification regime according to SPI indices are presented in **Table 1**.

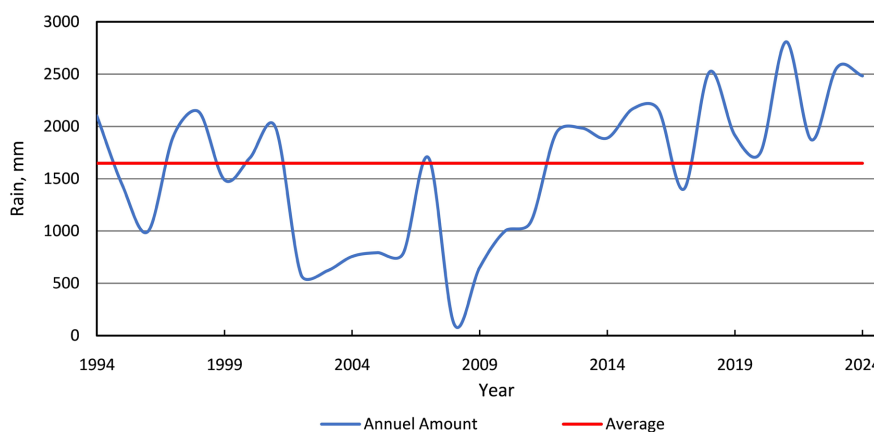
2.3. Results and Discussion

Analysis of interannual variations in total precipitation in the Faranah region shows two periods of fluctuation relative to the normal value of 1,647 mm (**Figure 2**).

Table 1. Classification of droughts based on the Standardised Precipitation Index (SPI).

SPI Assessment	Drought class
$SPI > 2$	Very damp
$1.5 < SPI \leq 2$	Damp
$1 < SPI \leq 1.5$	Moderately damp
$-1 < SPI \leq 1$	Normal
$-1.5 < SPI \leq -1$	Moderate drought
$-2 < SPI \leq -1.5$	Severe drought
$SPI \leq -2$	Very severe drought

Overall, below-normal rainfall was observed between 2002 and 2011, while above-normal rainfall was recorded between 2012 and 2024, with a slight decrease in 2017. In other years, rainfall patterns varied from the climate norm, with the minimum recorded in 2008 and the maximum in 2021.

**Figure 2.** Inter-annual precipitation values between 1994 and 2024.

The above data show the instability of the interannual rainfall pattern in Faranah: the annual average is 1,630 mm, the minimum annual rainfall is 25 mm and the maximum annual rainfall is 2,800 mm (**Figure 2**). During the year, maximum precipitation falls in August, with approximately 428 mm, and minimum precipitation in December (**Figure 3**).

It can be claimed that there are two seasons based on rainfall patterns: the rainy season, from May to October, and the dry season, from November to April. The rainy season lasts 5 to 6 months. Maximum annual rainfall is observed in August (443.20 mm) with a temperature of +23.6°C, and minimum rainfall in December (2.60 mm) with an average temperature of +22.5°C.

The annual distribution of air temperature in Faranah between 1994 and 2024 shows that the maximum temperature is observed in April, at the end of the dry season (**Figure 3**). With the increase in rainfall, temperatures drop until August, and a second small peak in temperature occurs in October. The winter months

are characterised by the lowest temperatures of the year.

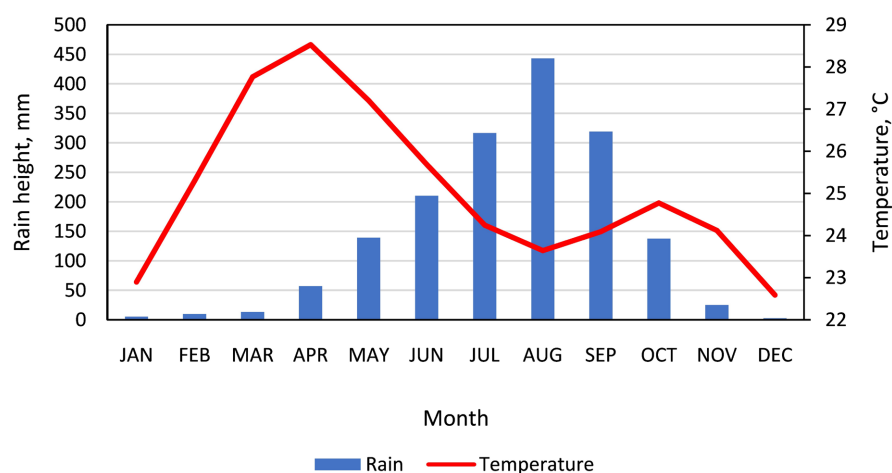


Figure 3. Ombrothermic diagram of the Faranah region between 1994 and 2024.

In Faranah, seasonal rainfall varies between 3 mm and 465 mm. The lowest seasonal rainfall is recorded between December and February, and the highest between July and September. A comparison of the averages for the periods 1994-2003, 2004-2013 and 2014-2024 indicates a decrease in total rainfall from August to January, with the dry season beginning in November. From January onwards, rainfall gradually increases until July. The dry season ends in April and the rainy season begins in May (**Figure 4**).

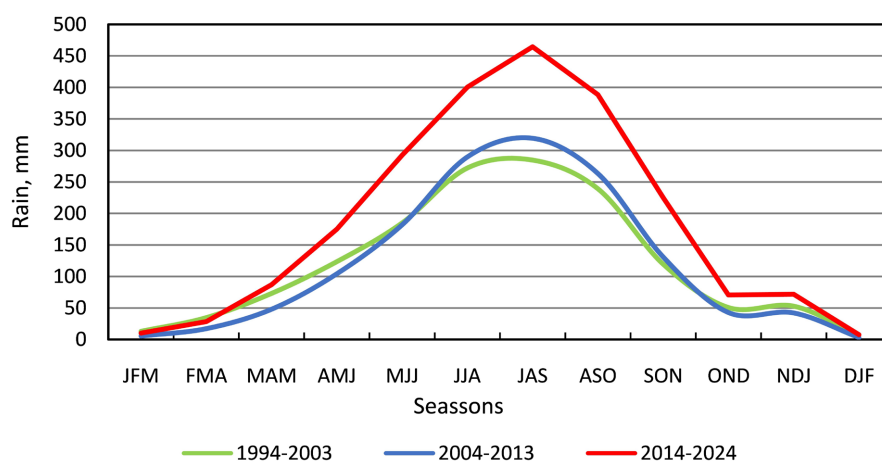


Figure 4. Cumulative seasonal rainfall for three periods in the Faranah region, 1994-2024.

The local temperature is actually the result of global radiation (solar and infrared) and the heat balance of land areas.

In 2007, the Intergovernmental Panel on Climate Change (IPCC) predicted that warming in the 21st century would be strongest over land and in the highest northern latitudes. Over the next two decades, warming of approximately 0.2°C per decade is expected.

However, temperatures in the Faranah region are slightly moderated by vegetation and high humidity. The maximum temperature, above $+33^{\circ}\text{C}$, is higher than in the coastal area. The average annual temperature is around $+38^{\circ}\text{C}$. Minimum temperatures rarely fall below $+12^{\circ}\text{C}$, accompanied by heavy rainfall in July, August, September and December-January, due to the Harmattan wind [7]. The highest temperatures are recorded at the end of the dry season. The average maximum is $+33.6^{\circ}\text{C}$ in January and rarely exceeds this value.

Statistical analysis of air temperature characterises the frequency of certain threshold values necessary for evaluating the thermal regime.

Maximum temperatures vary between $+29.8^{\circ}\text{C}$ and $+38.8^{\circ}\text{C}$. The maximum temperature is higher during the dry season (November-February) and lower during the wet season (July-August) (Figure 5). Annual minimum temperatures between 1994 and 2024 in the Faranah region vary between $+12.0^{\circ}\text{C}$ and $+21.3^{\circ}\text{C}$. They are lowest in January and highest in May (Figure 5). The temperature range is variable in winter (December, January and February), while in summer it varies very little (Figure 6).

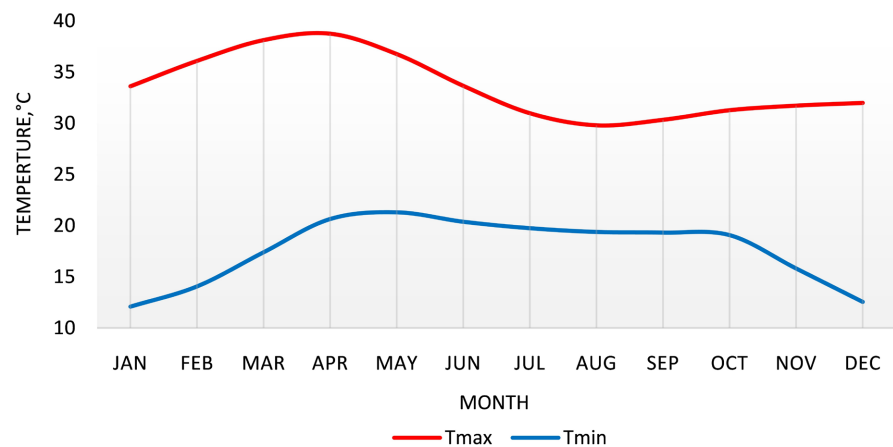


Figure 5. Annual changes in extreme temperatures for the period 1994-2024 in the Faranah region.

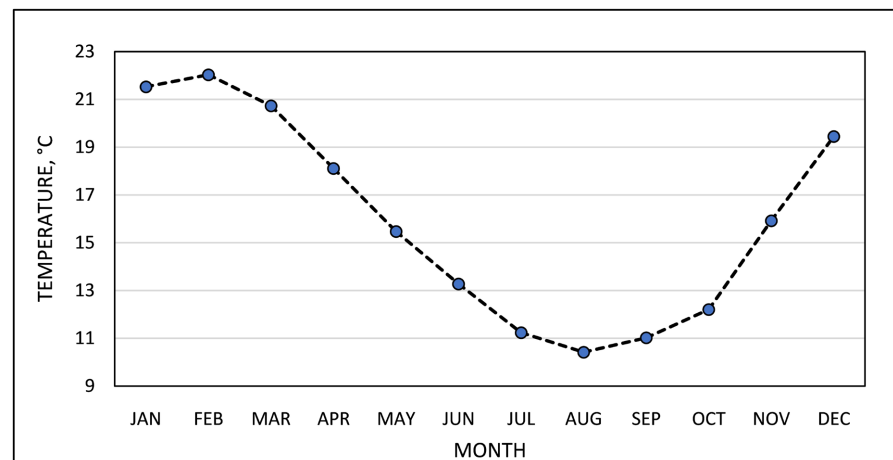


Figure 6. Air temperature range from 1994 to 2024 in the Faranah region.

Data from the ECMWF intermediate reanalysis (ERA) show that 2010 ranks second among the warmest years on record, with the difference between it and 2005 falling within the margin of uncertainty.

The decade 2001-2010 was also the warmest on record. This result is confirmed by examples from the northern hemisphere and Africa, where the regional temperature in 2010 was the warmest on record [16].

An important agroclimatic indicator is the sum of active temperatures during the peak growing season, from May to October. The results of the SAT calculation from 1994 to 2024 are shown in **Figure 7**.

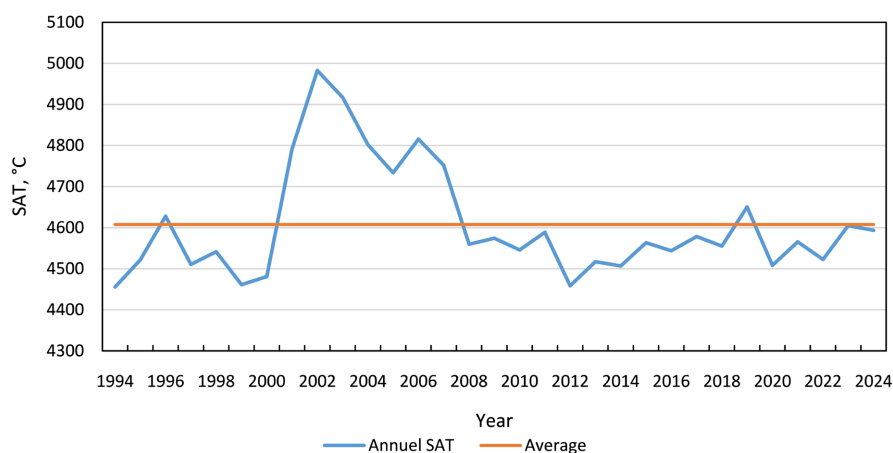


Figure 7. Multi-year evolution of the SAT.

According to the multi-year curve of the sum of active air temperatures (SAT), the maximum values were observed between 2002 and 2007, when they exceeded normal climatic values. After 2007 and until 2024, air temperature values were below normal climatic values, except in 2019.

In accordance with (formula 1), Selyaninov's hydrothermal coefficient (GTK) is calculated from the SAT values obtained and the cumulative precipitation during the growing season. The results obtained (**Figure 8**) indicate a trend

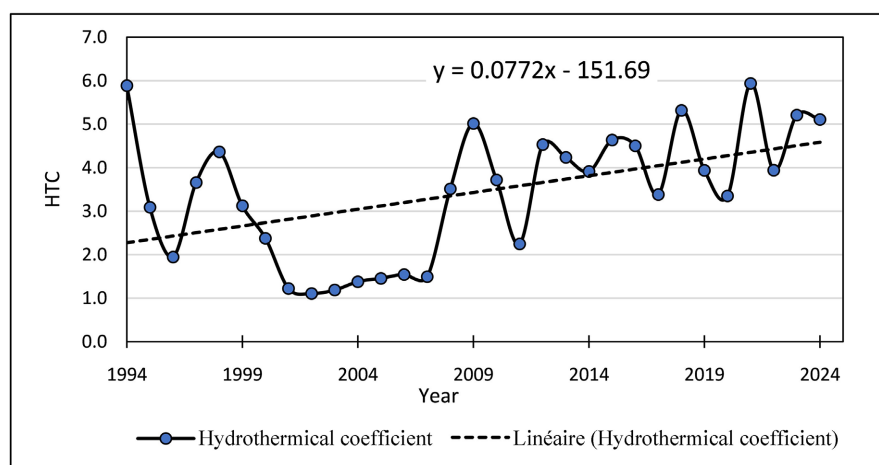


Figure 8. GTK values in the Faranah region over time.

towards an increase in multi-year GTK coefficients. Overall, the period from 1994 to 2024 is characterised by relatively wet values, but the period from 2001 to 2007 was slightly dry.

As indicated above, the SPI index is also analysed to characterise humidity. Analysis of the Standardised Precipitation Index (SPI) for the Faranah region (**Figure 9**) over 30 years (1994-2024) shows that the main positive precipitation anomalies range from 1.02 to 2.26.

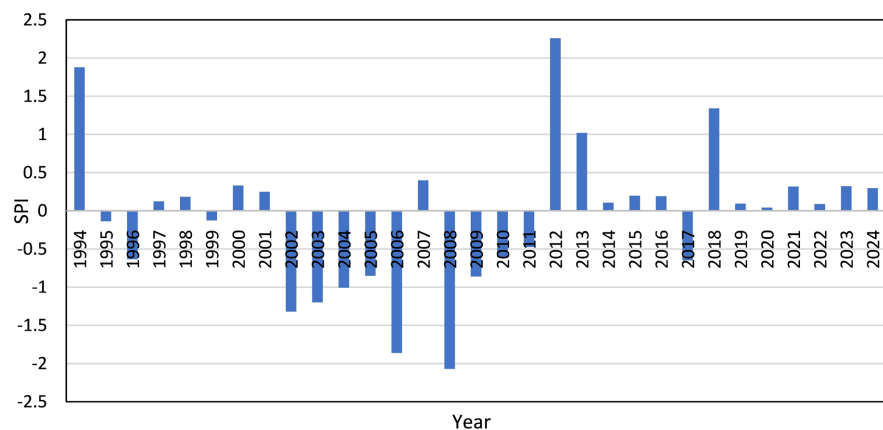


Figure 9. Evolution of the SPI value for the Faranah region.

The most significant positive anomalies in terms of intensity were those of 1994, 2012, 2013 and 2018, with respective indices of 1.88, 2.26, 1.02 and 1.34.

The most significant negative anomalies in terms of intensity were those of 2002, 2003, 2006 and 2008, with respective indices of -1.32 , -1.20 , -1.86 and -2.07 . The first decade in the Faranah region was characterised by increasingly abundant rainfall, followed by a dry period that coincided almost exactly with high STA values (see **Figure 7** and **Figure 9**). The dry period was followed by a slow increase in rainfall over the last decade, a result similar to that obtained in [17]. The platform and the associated environmental report (such as those from the WWF or IUCN) specify that this drought is mainly linked to anthropogenic factors such as agricultural expansion, wood energy production (charcoal) and bush fires often linked to land clearing [18].

During the analysis of interannual values for agro-meteorological characteristics from 1994 to 2024, we were able to establish a link between these parameters. To confirm the existence or absence of links between the parameters studied, we will use the correlation and regression analysis method.

According to the results of the correlation and regression analysis, the influence of STA on the SPI index is characterised by an inverse relationship. The polynomial function with a correlation coefficient of -0.56 should be chosen as the regression function (**Figure 10**). An increase in STA leads to a decrease in SPI, and therefore to an increase in the frequency of drought events.

Analysis of the correlation between the SPI and GTK indices shows that they are correlated with a coefficient of 0.58 and that the theoretical correlation line is

characterised by the regression equation of a direct linear dependence (Figure 11). This value of dependence between GTK and SPI justifies the use of Selyaninov's GTK to analyse the humidification regime in arid regions, and not only in temperate latitudes.

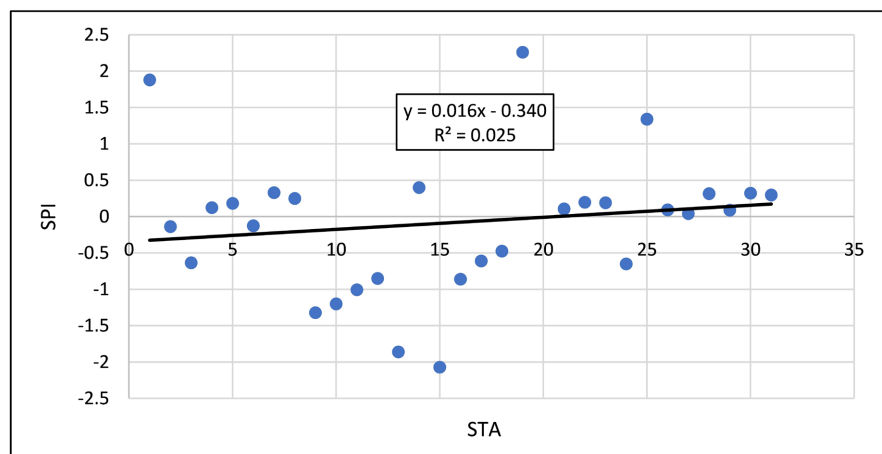


Figure 10. Correlation between SPI value and STA in the Faranah region.

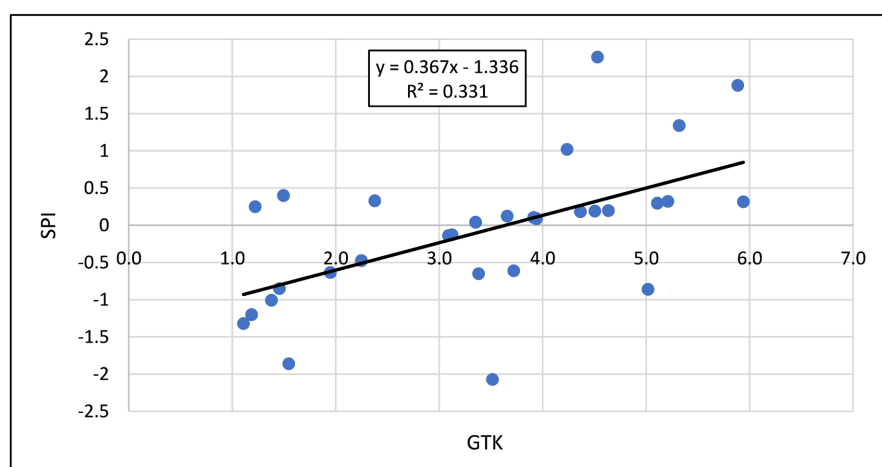


Figure 11. Correlation between SPI value and GTK in the Faranah region.

3. Conclusions

Analysis of climate variability in the Faranah region reveals the variability of meteorological parameters and agrometeorological characteristics that determine agroclimatic resources.

Analysis of the multi-year dynamics of meteorological and agrometeorological indicators shows their significant interannual variability. This variability is particularly characteristic of precipitation patterns and agrometeorological indices related to precipitation (GTK and SPI).

In the Faranah region, three main periods can be distinguished between 1994 and 2024: a wet period from 1994 to 2000, a dry period from 2001 to 2007, and a relatively unstable period from 2007 to 2024.

The sum of active temperatures during the growing season for the period studied is characterised by relative stability within the limits of the climatic norm, with the exception of the period from 2001 to 2008, when the STA significantly exceeded the climatic norm throughout the period.

The evolution of the parameters studied over time can be explained by the influence of climate change. This process is exacerbated by human activity (deforestation, greenhouse gas emissions, etc.), which is why it is necessary to develop measures to mitigate the effects of climate change in order to adapt agricultural production to meteorological and climatic risks.

Conflicts of Interest

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

References

- [1] Intergovernmental Panel on Climate Change (IPCC) (2022) Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. <https://doi.org/10.1017/9781009325844>
- [2] Affoh, R., Zheng, H., Dangui, K. and Dissani, B.M. (2022) The Impact of Climate Variability and Change on Food Security in Sub-Saharan Africa: Perspective from Panel Data Analysis. *Sustainability*, **14**, Article 759. <https://doi.org/10.3390/su14020759>
- [3] Tessema, I. and Simane, B. (2019) Vulnerability Analysis of Smallholder Farmers to Climate Variability and Change: An Agro-Ecological System-Based Approach in the Fincha'a Sub-Basin of the Upper Blue Nile Basin of Ethiopia. *Ecological Processes*, **8**, Article No. 5. <https://doi.org/10.1186/s13717-019-0159-7>
- [4] Kourouma, J.M. (2015) Study of the Vulnerability of Agriculture to Climate Change in Forest Guinea: For Farmers in Peri-Urban Rural Areas of the Municipality of N'Zérékoré South-Eastern Guinea. Ph.D. Thesis, Centre Regional Agrhymet. (In French)
- [5] Thurlow, J., Zhu, T.J. and Diao, X.S. (2009) The Impact of Climate Variability and Change on Economic Growth and Poverty in Zambia. International Food Policy Research Institute. <https://hdl.handle.net/10568/161986>
<https://cgspace.cgiar.org/items/a5e04f8b-0409-4fd7-83f1-35f224ca03d7>
- [6] Traoré, A.F., Diallo, M.L., Bamba, Z. and Mara, F. (2002) Initial Communication in Guinea to the Framework Convention United Nations Change Climate. Ministry of Mining, Geology and Environment. (In French)
<https://unfccc.int/resource/docs/natc/guinc1.pdf?utm>
- [7] Jalloh, A., Nelson, G.C., Thomas, T.S., Zougmore, R. and Roy-Macauley, H. (2013) West African Agriculture and Climate Change: A Comprehensive Analysis. International Food Policy Research Institute.
- [8] CEDEAO-CSAO/OCDE (2008) Climate and Climate Changes. Environment Series, Oest Africa Regional Integration Atlas. (In French)
<https://www.oecd.org/fr/about/directorates/sahel-and-west-africa-club.html>
- [9] Brown, O. and Crawford, A. (2008) Climate Change: A New Threat to Stability in West Africa? Evidence from Ghana and Burkina Faso. *African Security Review*, **17**, 39-57. <https://doi.org/10.1080/10246029.2008.9627482>

- [10] Ackerl, T., Weldemariam, L.F., Nyasimi, M. and Ayanlade, A. (2023) Climate Change Risk, Resilience, and Adaptation among Rural Farmers in East Africa: A Literature Review. *Regional Sustainability*, **4**, 185-193.
<https://doi.org/10.1016/j.regsus.2023.05.004>
- [11] Beavogui, M. (2012) Impacts of Climate Change on the Cultivation of Upland Rice in Upper Guinea and Proposed Adaptation Strategies. Ph.D. Thesis, Agrhyment Regional Centre. (In French)
<https://fr.scribd.com/document/949597352/Memoire-Riz-impacts-changement-climatiques?utm>
- [12] Ministry of Agriculture, Livestock, Environment, Water and Forests (2007) National Action Plan for Adaptation to Climate Change of the Republic of Guinea. (In French)
<https://unfccc.int/resource/docs/napa/gin01f.pdf?utm>
- [13] Loua, R.T., Beavogui, M., Bencherif, H., Barry, A.B., Bamba, Z. and Mazodier, C.A. (2017) Climatology of Guinea: Study of Climate Variability in N'zerekore. *Journal of Agricultural Science and Technology A*, **7**, 215-233.
<https://doi.org/10.17265/2161-6256/2017.04.001>
- [14] World Meteorological Organization (WMO) (2011) WMO Statement on the Status of the Global Climate in 2010. WMO No. 1074.
https://library.wmo.int/viewer/56348/download?file=wmo_1074_en.pdf&navigator=1&type=pdf&utm
- [15] Грингоф, И.Г. and Павлова, В.Н. (2013) Основы Сельскохозяйственной Метеорологии. Том III. Часть 1. Основы Агроклиматологии. Часть 2. Влияние изменений климата на экосистемы, агросферу и сельскохозяйственное производство. Обнинск: ФГБУ «ВНИИГМИ-МЦД», 384 p.
<https://mgmtmo.ru/edumat/agro/agroclimatology.pdf?utm>
- [16] World Meteorological Organization (WMO) (2011) Knowing Climate for Action: A Global Framework for Climate Services to Strengthen the Position of the Most Vulnerable. OMM No. 1066. (In French)
https://library.wmo.int/pmb_ged/wmo_1066_fr.pdf
- [17] Haba, S., Bamba, Z., Diaby, I. and Mansaré, T. (2022) Caractérisation de la fluctuation pluviométrique de la Guinée à l'aide de l'indice standardisé de la précipitation (SPI). *Afrique SCIENCE*, **21**, 102-112.
<https://www.afriquescience.net/admin/post-pdfs/4300ac52b2417fd51865a98f236f91111719976601.pdf>
- [18] Global Forest Watch (n.d.) Faranah, Guinea—Deforestation Rates & Statistics [Tableau de bord interactif].
<https://www.globalforestwatch.org/dashboards/country/GIN/3/?dashboardPrompts>