ГЛАСНИК Српског географског друштва 104(2) 245-256
BULLETIN OF THE SERBIAN GEOGRAPHICAL SOCIETY 2024

Original scientific paper UDC 551.577.37(662.5)
https://doi.org/10.2298/GSGD2402245K

Received: August 15, 2024
Corrected: September 22, 2024
Accepted: October 11, 2024

Bienvenue Lawankiléa Chantal Noumpoa Karambiri[1*]

** Institute of Social Sciences (INSS/CNRST), Burkina Faso*

VARIABILITY OF CLIMATIC PARAMETERS IN TIEFORA, BURKINA FASO: SCIENTIFIC ASPECTS AND FARMERS' PERCEPTIONS

Abstract: The evolution of climatic parameters is of major importance for the populations of the Sahel, and in particular Burkina Faso, whose agricultural production is predominantly rain-fed. The aim of this study is to analyze the variation in climatic parameters in the rural commune of Tiéfora in Burkina Faso. Climatic data from 1991-2020 were collected from the National Meteorological Agency (ANAM). In addition, individual questionnaire surveys were carried out among 100 local people. The results show that from 1991 to 2020, 19 out of 30 years had rainfall in excess of 1000 mm. The area experienced 16 years of rainfall surpluses, compared with 14 years of rainfall deficits. In terms of temperature, the annual average rose from 27.08°C to 28.43°C from 1991 to 2020, a difference of 1.35°C. This indicates a rise in temperature. Other climatic parameters (wind, humidity and ETP) have also varied in the area, with an increase. The people of Tiéfora perceive this rise in temperature and a fall in rainfall.

Key words: Burkina Faso, climate, rainfall, temperature, evapotranspiration

[1] bienvenuechantal@gmail.com (corresponding author)
Bienvenue Lawankiléa Chantal Noumpoa Karambiri (https://orcid.org/0009-0000-7540-5473)

Introduction

One of the major challenges facing mankind is undoubtedly the problem of climate variability. Several studies on climate variability have been carried out worldwide, including those by Boé (2007) in France and Rivard, et al. (2003) in Canada. Analysis of climate trends based on climate models and climate change scenarios indicate changes in temperature and rainfall. Projections for the whole country point to an increase in average temperatures of 0.8°C by 2025 and 1.7°C by 2050 (Traoré, 2017). As a result, the Permanent Inter-State Committee for Drought Control in the Sahel - [CILSS-AGRHYMET] (2010) predicts that in the coming years, we can expect contrasting situations alternating between drought and rainfall surpluses.

Sub-Saharan Africa is sensitive to climate variability. Climate change, particularly the decline in rainfall, is causing major ecological imbalances (Assemian et al., 2013). In addition to rainfall, potential evapotranspiration and relative air humidity are climatic parameters with impacts on several sectors of activity (Faurie et al., 2011).

The succession of droughts in Burkina Faso between 1970 and 1980 resulted in the degradation of ecosystems and a reduction in productive potential (Ilboudo et al., 2020). Indeed, several areas of the country are confronted with this climatic variability. The Sanguié province area experienced a drop-in rainfall and temperature from 1998 to 2008, with a downward trend in rainfall and an upward trend in temperature (Karambiri, 2020).

In this context, making a diagnosis of the evolution of climatic parameters and comparing it to the perception of the population can help local populations to be confident in their climate forecast. Tiéfora is an agricultural commune, and climate variability can have an impact on production. If people are aware of this reality, they will take adaptive measures to cope with this climatic variation. The objective of this research is to analyze the variation in climatic parameters in the rural commune of Tiéfora in Burkina Faso. This will be done using a qualitative and quantitative method.

Methodology

Geographical context

The rural commune of Tiéfora is located between latitude 10°37'59" North and longitude 4°33'00" West. This commune is located in the Comoé province, Cascades region. It covers a total area of 1,073 km², or 6.77% of the province's total surface area. Fig. 1 shows the location of the study area. The area's climate is characterized by two seasons. A rainy season lasting five months (May to September) and a dry season lasting seven months (October to April). The dry season is characterized by a cold, dry wind (harmattan) blowing from northeast to southwest. This wind scours the bare soil caused by poor farming practices.

The commune lies between the 800 mm and 1200 mm isoete and is relatively well-watered, but there is a poor spatio-temporal distribution of rainfall, which has a negative impact on agro-sylvo-pastoral activities in the commune. Average annual rainfall from 2011 to 2020 was 1125.62 mm for an average of 65 rainy days, and rainfall amounts varied between 803.5 and 1480 mm. Average annual temperatures range from 16° to 36°C, with a temperature range of 20°C. The coldest months are December to February, and the hottest are March to June. The uneven distribution of rainwater, temperature and wind can lead to the degradation of water, soil and vegetation resources.

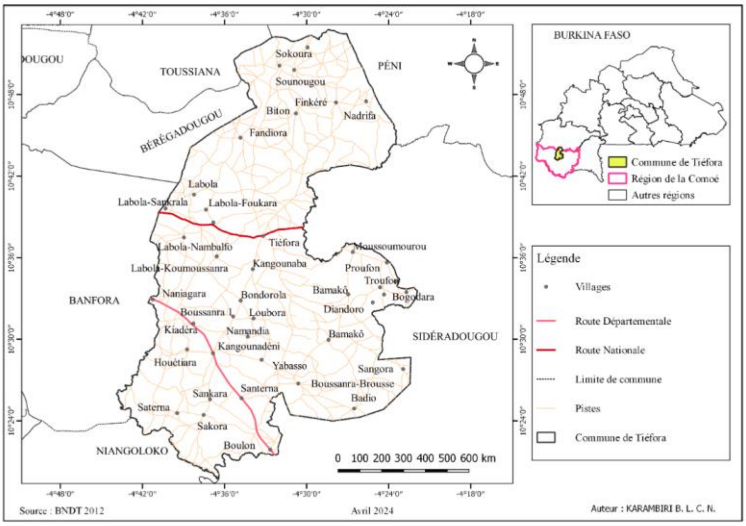

Fig 1: Location of the commune of Tiéfora (Source: BNDT 2012)

Data collection

To carry out this study, climate data from 1991-2020 were collected from the National Meteorological Agency (ANAM). The parameters concerned are: rainfall, temperature, air humidity and wind direction. These data provide a scientific assessment of climatic variability in the commune of Tiéfora. These data are provided by two synoptic stations (Banfora and Bobo-Dioulasso). Banfora is home to only one synoptic rainfall station, which covers the commune of Tiéfora, while Bobo-Dioulasso is the only synoptic station close to Banfora with temperature, air humidity and wind data.

In addition to climate data, individual questionnaire surveys were carried out among 100 people to ascertain their perception of climate change. Only people over the age of 30 were surveyed. This choice is explained by the need to be able to see perception over a certain period. As for the choice of respondents, these people were surveyed according to their availability and their willingness to answer the questionnaire. This can be explained by the insecurity that makes people suspicious and often reluctant to take part in surveys.

Data processing

The data show the evolution of the climate over 30 years. To show the variation in rainfall, the standardized rainfall index (SRI) and the evolution of annual rainfall quantities. This index is used to calculate climate variability over the 30 years (1991-2020). This index shows the trend and irregularity of precipitation. This index is used to analyze dry periods or cycles (World Meteorological Organization [WMO], 2012). Positive values of the index indicate precipitation above the median and negative values indicate precipitation below the median. Also, it indicates that a drought begins when its value is less than or equal to -1.0 and that the drought ends when its value becomes positive. The formula given by (OMM, 2012) is from (Nicholson et al., 1988) which defines the following relationship: $PSI = Xi - Xm / \sigma i$ with Xi the cumulative rainfall for a year, Xm and $/\sigma i$ respectively the mean and standard deviation of the annual rainfall observed for the series observed. The PSI analysis is based on value slicing. The table below shows the breakdown of values. Positive values indicate humidity, while negative values indicate dryness.

The characterization of potential evapotranspiration variability uses daily rainfall data per decade and ETP (evapotranspiration) data via the Cochème and Franquin curve (Cocheme & Franquin, 1967). This curve has enabled us to divide the rainy season into five periods: false starts, the pre-wet period (start of agricultural activities), the wet period (useful for plants), the post-wet period and the end of the useful period, which corresponds to the end of agricultural activities.

Results

Rainfall trends

The trend in rainfall over the last three decades shows an inter-annual variation in rainfall and a general trend (Fig. 2). Over the last three decades, 19 out of 30 years have seen rainfall in excess of 1000 mm. Intense rainfall variation can be seen in the years (2006, 2008, 2018, 2020) that mark the rainy years with rainfall above 1200 mm (P ≥1200 mm). In addition, 11 of the 30 years have a water volume of less than 1000 mm. The years 1996, 2001, 2009 saw low rainfall with (P≤ 800 mm). Annual rainfall trends show that rainfall varies from year to year. Rainfall has also been irregular over these 30 years.

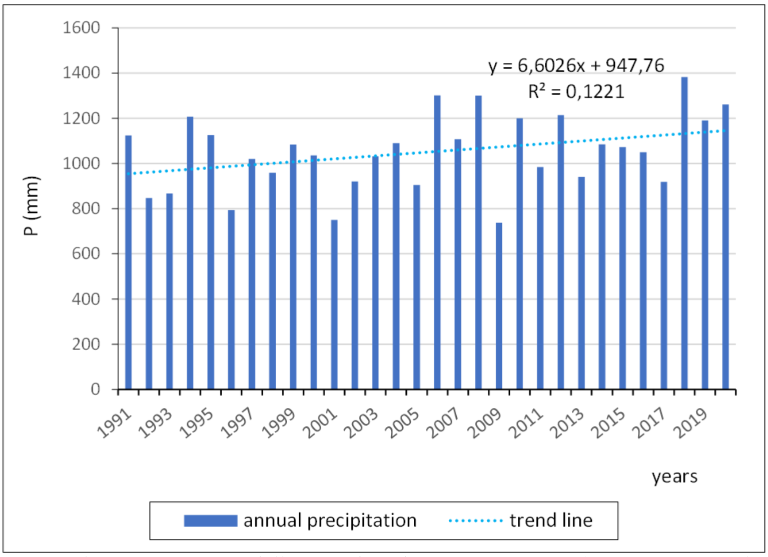

Fig 2: Interannual variation in rainfall in Banfora from 1991 to 2020 (Source: National Meteorological Agency, 2022)

ISP analysis can be used to determine periods of surplus and deficit in the climate of a given location. Fig 3 shows two distinct phases in the evolution of rainfall. The first phase is marked by surplus periods from 1991 to 2020, interspersed with deficit periods. The years (1994, 2006, 2008, 2012, 2018, 2020) with the highest surpluses include 2018, which is extremely wet, and 2015, which is close to normal. The second phase is marked by deficit periods from 1992 to 2017, which are also interspersed with surplus periods. The years (1992, 1993, 1996, 2001, 2009) were marked by severe rainfall deficits, with 2009 being a very dry year and 2000 a near-normal year. Annual rainfall surpluses and deficits are irregular throughout the series. The correlation coefficient does not reveal a trend. This rainfall irregularity has an impact on the area's agricultural production, which is essentially rain-fed.

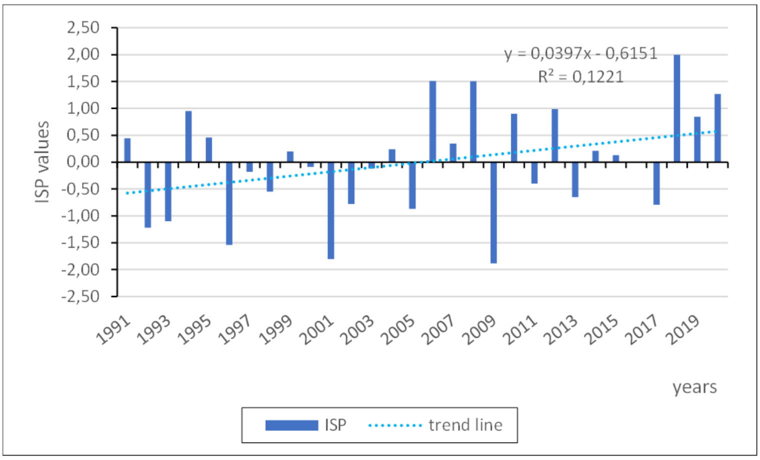

Fig. 3. Changes in Banfora's standardized rainfall index from 1991 to 2020 (Source: National Meteorological Agency, 2022)

Temperature trends

The mean annual temperature gives the general energetic state of an area over time. Fig 4. shows the evolution of the mean annual temperature. It varies from a maximum (28.43°C) in 2002, 2005, 2016 with the years (2001, 2003, 2004, 2010, 2013, 2014, 2015, 2017, 2018, 2019, 2020) to a minimum (27.08°C) in 1992. The average temperature rose from (27.08°C to 28.43°C) from (1991 to 2020), a difference of (1.35°C). This increase shows a rise in temperature over the 30 years, with a general upward trend and a constant annual average (27.9°C). This rise in temperature could have an impact on agricultural production in hot weather.

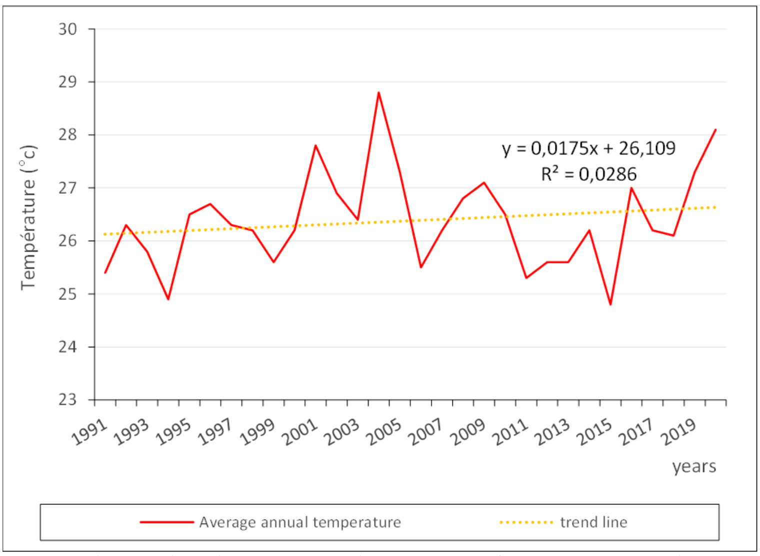

Fig. 4. Change in Bobo Dioulasso's mean annual temperature from 1991 to 2020 (Source: National Meteorological Agency, 2022)

Variations in evapotranspiration

The Cochème and Franquin curve can be used to determine the start and end of agricultural activity. Together with ETP and rainfall, it can be used to determine the pre-wet, wet, post-wet and dry periods in the series. Fig 5 shows the dry period from the second decade of October to the first decade of May. The pre-wet period runs from the second decade of May to the second decade of June. The wet period extends from the third decade of June to the third decade of September. The date of the wet period corresponds to the end of sowing. The sowing period therefore corresponds to the pre-wet period and the start of the wet period. The post-wet period extends into the first decade of October. The end of the useful period begins in the first decade of October. This useful period begins in the second decade of May and ends in the first decade of October. The third decade of September to the end of November marks the ripening and harvesting period, when humidity drops.

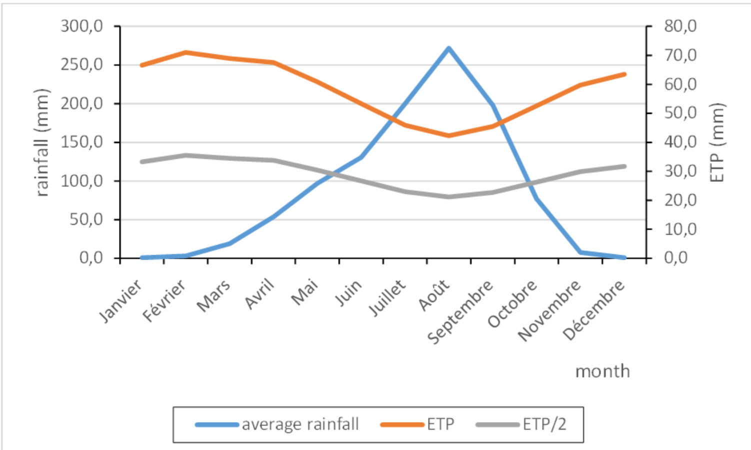

Fig. 5. Average monthly precipitation trends by decade from 1991 to 2020 (Source: National Meteorological Agency, 2022)

The first dry period (A). This is a period when people in the area are busy preparing their fields. The second, pre-wet period (B). From an agronomic point of view, this is the best time to start farming. This is the period when people start sowing in the fields. The third wet period (C). This corresponds to the period from mid-July to mid-September. It corresponds to the wintering period. The fourth, post-wet period (D). This is the period of harvest and the start of off-season crops.

Relative humidity trends

Fig 6 below shows the interannual average relative humidity. A drop in relative humidity can be seen from (2001 to 2003), (2006 to 2008), and (2015 to 2017) as values are below the normal threshold. A rise in humidity is observed in the years (1991, 1993,1995, 1997, 1998, 2012, 2013, 2014, 2018, 2020) and a clear change in humidity in (1994, 2000, 2004, 2005). The highest value in the series (58.5%) is in 2020 and the lowest (51.33%) in 2003. The difference is (7.17%). This evolution in relative air humidity could be favorable to natural resources (soil, vegetation, water).

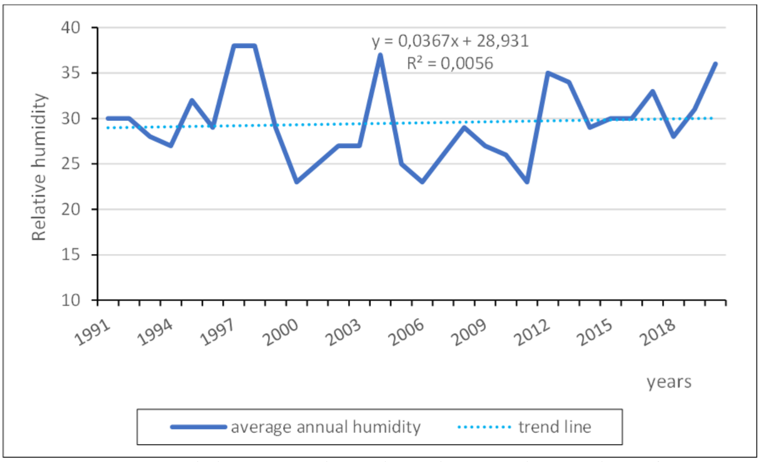

Fig 6: Average interannual change in relative humidity in Bobo Dioulasso from 1991 to 2020 (Source: National Meteorological Agency, 2022)

Evolution of wind speed

Wind speed has evolved discontinuously, but with a slight increase, as shown by the R2 correlation coefficient. The first variation was from 1991 (2.23 m/s) to 1995 (2.72 m/s), i.e. (0.49 m/s) below the normal average. The second variation runs from 1996 (3.19 m/s) to 2020 (2.85 m/s), i.e. a deviation of (-0.34 m/s) below normal. The second variation has decreased, but is still evolving compared to the first dekad. The strong wind had an impact on plans, especially at the end of the season. This has a major impact on harvests. The figure below shows wind speed in Bobo Dioulasso from 1991 to 2020.

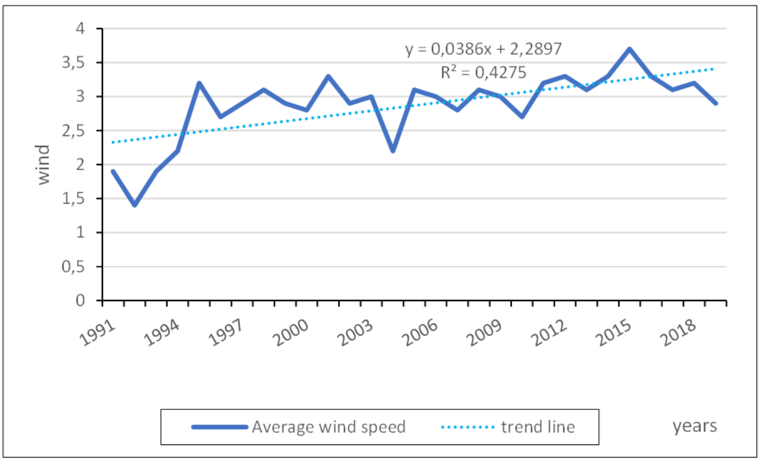

Fig. 7. Change in mean annual wind speed at Bobo Dioulasso from 1991 to 2005 (Source: National Meteorological Agency, 2022)

Farmers' perceptions of changes in climatic parameters

The summary shows the state of the climate in the area over the last 30 years. Rainfall has decreased according to (79%) of those surveyed, and (11%) of these people affirm that rainfall has increased. Only (10%) dispute the stability of rainfall. Contrary to the data provided by ANAM, we were unable to detect any trend in rainfall over the last 30 years. This reflects the farmers' poor perception of the rainfall parameter. According to (80%) of those surveyed, the temperature has increased over the last 30 years. For (15%) of these people, the temperature has fallen, while (5%) have no answer or don't know. There is a good perception on the part of the farmers, since the data provided by the weather station show the evolution of the temperature, as does the population.

Air humidity has fallen according to (80%) of those surveyed, and (12.3%) confirm that it has risen. Only (7.7%) gave no answer. People have a poor perception of the data from the meteorological station, which shows that there is no trend in the evolution of air humidity.

Wind speed has changed for (83%) of respondents. For (15.5%) wind speed has decreased and (1.5%) "don't know". There is a good perception of the farmers who confirm the increase in wind speed by ANAM (National Meteorological Agency). Of the climatic parameters (rainfall, temperature, humidity, wind), only two showed a positive change in farmers' perception. Tab 1 summarizes people's perceptions of climatic parameters.

Tab 1: Summary of climatic parameters over the 30 years

Climatic parameters	30-year trend		Farmers' perception	Percentage (%)
	Increase	Decrease		
Rainfall	Yes	No	Decrease	79%
Temperature	Yes	No	Increase	80%
Relative air humidity	Yes	No	Decrease	80%
Wind	Yes	No	Increase	83%

Source: Field survey, 2022

Farmers' perceptions of climate variability show a drop in rainfall and humidity, and an increase in temperature and wind. Populations have difficulty in perceiving rainfall and humidity. Variations in these climatic parameters alter the course of the crop season, resulting in lower yields. However, people perceive the good season as increasing yields, which could justify their poor perception. This has led them to adopt certain farming techniques in order to achieve good yields. Changes in farming techniques, combined with changes in climatic parameters, are contributing to the degradation of natural resources. These farming techniques include the use of ploughs and tractors, chemicals (herbicides, pesticides, fertilizers) and organic fertilizers. The use of herbicides and fertilizers enables good yields, as does the use of organic manure. But fertilizers, herbicides and pesticides are contributing to climate change, which is having an impact on climatic parameters by causing a rise in temperature, a drop in rainfall in places, violent winds and an increase in extreme weather phenomena such as floods and droughts. In September 2024, the area was severely flooded, with disastrous consequences (ponds collapsed, fields and dwellings engulfed by the waters). On the other hand, the use of organic manure, which is a natural product, has no impact on the environment. With regard to the degradation of natural resources, there has been a regression in the savannah trees and shrubs, as well as the forest. There is also soil degradation.

Discussion

We note an intense variation in rainfall during the years (2006, 2008, 2018, 2020). This result corresponds to those of Bambara et al, 2019 in the Ouahigouya and Ouagadougou areas. For these authors, rainfall amounts were higher in Ouagadougou than in Ouahigouya, 789.3 mm over the reference period.

The area experienced both surplus and deficit periods. In fact, there is an annual irregularity between surplus and deficit periods in the zone. This result is similar to that of Karambiri (2017) in the Sourou watershed in Burkina Faso. In fact, the author found that the frequency of deficit years was greater than that of normal, surplus years, i.e. twenty-two compared with twenty-one over the 39 series under consideration. Despite the length of the series and the climatic zone which differs from the present study, the results show an irregularity in climatic parameters. Other authors, such as Ilboudo (2023), have found similar results in the North Sudanian zone of Burkina Faso. Temperature also varies in the Tiéfora zone. Indeed, the average temperature rose from (27.08°C to 28.43°C) from (1991 to 2020), a difference of (1.35°C). This increase shows a rise in temperature over the 30 years, with a general upward trend. This result is in line with studies by Rouamba (2017) and Ouédraogo (2015) in Ouagadougou and the Yakouta watershed in Burkina Faso respectively. All these authors agree that the temperature varies with an upward trend. The Tiéfora area, which is an agricultural zone and makes a major contribution to food security in Burkina Faso, is experiencing the same realities.

The pre-wet period runs from the second dekad of May to the second dekad of June. The wet period extends from the third dekad of June to the third dekad of September. The post-wet period extends from the first dekad of October. The end of the useful period begins in the first dekad of October. These results are in line with those of Karambiri (2017) and Lompo et al. (2022). In the Sourou watershed, Karambiri (2017) found that the pre-wet period runs from mid-June to mid-July, the wet period from mid-July to mid-September and the post-wet period from mid-September to the last dekad of October. The author shows that during these periods, growers are busy preparing their fields and carrying out intense agricultural activity, as in Tiéfora. Lompo et al. (2022) report the same results for Burkina's northern climatic zone, which is adjacent to the southern Sudanian zone to which Tiéfora belongs.

A drop in relative air humidity was observed. Several authors have reached the same conclusions. Such is the case of Sanogo et al. (2024) in the commune of Bérégadougou in Burkina Faso. The authors show that the 1996 sesame season had the highest relative humidity (65.30%), while that of 2021 was the lowest (57%).

In addition to the scientific findings showing a rise or fall in climatic parameters, the local population also notes a variation in climatic parameters. Indeed, the population of Tiéfora has noted a drop-in rainfall. This result is similar to those of Karambiri et al. (2022), who show that in the Sanguié province of Burkina Faso, people have a good perception of rainfall. They feel that rainfall has fallen in their area, impacting many activities, especially agriculture.

The people of Tiéfora have also noticed a rise in temperature. This rise was also found by scientific observation. This result corresponds to those of Sanogo et al. (2024), who found a rise in temperature in the commune of Bérégadougou in western Burkina Faso. This shows that in both studies, populations in the same climatic zone had the same perception of temperature variation. Therefore, the studies which found that populations have a good perception of the variation of certain climatic parameters are true. Variations in these climatic parameters modify the course of the crop season, with consequent impacts on production. This result corroborates those of Sanogo et al. (2024), who showed the impact of climatic variability on sesame production in Bérégadougou, Burkina Faso.

Other authors such as Yaméogo et al. (2024) have also shown rainfall variability with an impact on agricultural activities in the Vranso watershed in Kurkina Faso. Authors such as El Karfa et al. (2023) also show a regressive rainfall trend in the Gharb plain in Morocco. Djohy et al. (2015), found that the traditional agricultural calendar is subject to readjustment, depending on people's perception of climate change towards new climatic balances. Moreover, Yanogo et al. (2023) found similar results in the southwest and north of Burkina Faso. These authors found a decrease in the frequency of intense precipitation and maximum daily precipitation. All these studies are unanimous in pointing out that populations share the same perception of the social problems linked to climate variability. These social problems include lower agricultural yields, with the corollary of lower producer incomes. A drop-in people's income will lead to a drop in their standard of living.

Conclusion

Climatic parameters in the Tiéfora area vary greatly in time and space. Rainfall, the parameter with the greatest impact on agricultural production, has fluctuated between surpluses and deficits from one year to the next. But over the series, the number of years with rainfall surpluses is higher than the number of years with rainfall deficits. This situation is favourable for agricultural production. Temperatures have been fluctuating, with an upward trend. This situation is not favourable to production. Wind speed has been trending upwards. Strong winds impact crops. In addition to the scientific aspect, the local population had the same perception of the evolution of climatic parameters. According to them, temperatures and winds are on the rise. The only difference is that the local population found a downward trend in precipitation, but with the scientific analysis, the rainfall trend is not detectable. The evolution of climatic parameters in Tiéfora is important for the global community, as climate variability is a worldwide phenomenon. A study in one area can help another area take precautions to cope with this natural phenomenon, which spares no community. In many communities, agriculture is essentially rain-fed, as in Tiéfora. Knowledge of the evolution of these climatic parameters will enable scientists to propose adaptation strategies to increase agricultural yields. Increased yields will contribute to achieving food self-sufficiency and boosting local incomes through the sale of surplus foodstuffs.

Conflicts of Interest: The author declares no conflict of interest.

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