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STRENGTHENING CLIMATIC RESILIENCE BY DEVELOPING LOWLANDS IN THE RURAL COMMUNE OF BILANGA, EASTERN REGION OF BURKINA FASO

Abstract: The use of inland valleys plays a key role in agricultural relations in the rural commune of Bilanga and remains a decisive factor in the control of agrarian space on all family farms, in a context of climatic variability. The use of lowlands is one of the resilience strategies adopted by the population of Bilanga in the face of climatic variability. The aim of this article is to analyse the strengthening of climatic resilience through the development of inland valleys in the rural commune of Bilanga. To achieve this objective, the methodological approach was based on the analysis of meteorological data (1994-2023) of climatic elements (rainfall, temperatures, relative humidity, insolation, winds) and farmers' perceptions of the strengthening of climatic resilience thanks to the development of lowlands. The investigations showed that the scientific view of climate variability is in line with the farmers' perception (96%). In addition, 89% of family farmers stated that the use of inland valleys contributes to the climate resilience of the Bilanga farming community. In addition, 89% of farmers said that the development of inland valleys was a response to the decline in soil fertility as a result of overexploitation and extreme weather events. The development of lowlands could therefore be an opportunity to achieve food security in the rural commune of Bilanga, as in other rural communes in Burkina Faso.

Keywords: population of the study area, farmers' perception of climate variability, inland valleys, climate variability, climate adaptation

Introduction

Change in the climate system is unequivocal, as we are already seeing a rise in the average temperatures of the atmosphere and the ocean. In addition, observations made on all continents and in most oceans show that a multitude of natural systems are being affected by climate change, particularly by rising temperatures (IPCC, 2014). The massive use of fossil

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fuels such as oil, coal and natural gas, which provide the energy needed to meet the needs of societies such as industrialisation, intensive agriculture, dependence on electricity, ever faster transport, etc., is one of the main causes of climate disruption (Viau, 2009). An FAO study (2008) on the specific effects of climate change on agriculture in developing countries reveals that, overall, the situation in African countries will worsen and that areas that are marginal today could become hostile to agriculture tomorrow.

Indeed, it is becoming increasingly clear that the limited capacity of populations to anticipate and reduce the impact of climate fluctuations is illustrated by the strong correlation between agricultural productivity and rainfall. This vulnerability to climate is also illustrated by the fact that, since the 1970s, the biggest famines to require international food aid (1974, 1984/1985, 1992 and 2002) have been entirely or partly due to climate variations (Gommes, 1993). Work carried out by the CILSS (2011), for example, confirms that although the 2010 food crisis in the Sahel, which affected more than a third of the population of West Africa, was caused by a number of factors (fluctuations in market prices, weakness of the water distribution network), it was triggered by a shortage of rain in 2009, which reduced the potential for agricultural production.

In Burkina Faso, climate variability is reflected in the disappearance of the 1400 and 1300 mm isohyets in the south of the country and the appearance of the 400 mm isohyet in the north (even 360 mm), reflecting an overall reduction in the amount of rain received. The trend towards aridification is causing serious water supply problems, disrupting the agricultural calendar and leading to changes in farming practices (ATLAS, 2001). In addition, to cope with this climate variability, populations adopt various strategies. Some authors Koudamiloro (2017), Tchoupé Makougoum (2018), N'drin et al. (2019), Zongo (2021), Ouédraogo (2023), Sanogo et al. (2024) have proposed adaptation strategies based on water and soil conservation techniques, the implementation of soil fertility restoration techniques, the use of organic manure and chemical fertilisers, agroforestry, crop combinations, changes to the agricultural calendar, the use of improved seeds and the use of lowlands. According to Sconnes (1992), lowlands are of paramount importance in agricultural and pastoral systems in the savannahs of Africa. They act as a key resource for farmers and pastoralists, providing a source of arable land or pasture during droughts or the dry season. These wetlands not only support the rural subsistence economy and contribute to food security, they also provide opportunities for crop diversification and generate a wide range of direct and indirect benefits.

Thus, the development of lowlands is a reality in all the rural communes of Burkina Faso. In fact, the issue of inland valley use plays a key role in agricultural relations in the rural commune of Bilanga and remains decisive in the control of agrarian space on all family farms (Sanogo, 2019). Subsequently, in order to master the contours of the issue of inland valleys in relation to climate variability, one question deserves to be asked:

How does the development of inland valleys in the rural commune of Bilanga contribute to climate resilience? The argument is based on the hypothesis that the development of inland valleys in the rural commune of Bilanga contributes to strengthening climate resilience. The aim of this article is to analyse the strengthening of climatic resilience through the development of inland valleys in the rural commune of Bilanga. To achieve this objective and test the hypothesis, a methodology was adopted for data collection. The presentation of the methodological approach is preceded by a statement of the theoretical framework.

Scope of the study

Theoretical framework

The research theme addresses the issue of lowland farming in a context of climatic variability in a Sahelian country. A number of authors have commented on this issue. Some authors have shown the impact of climate variability on the degradation of wetlands. Without being exhaustive, the work of Zaré (2015) on inland valleys in the inland delta of the Niger River in Mali in a context of climatic variability shows that the climatic issues in the exploitation of inland valleys seem very worrying and 'to reduce the vulnerability of production systems in the face of climatic variability, it is therefore necessary to mitigate the impacts of the irregularity of floods, rainfall and flooding, and to reduce climatic risk. It is therefore necessary to secure and control water on the one hand, and to anticipate and adjust production techniques with the help of climate forecasting. Research by Kobena et al. (2023) in central Côte d'Ivoire on climate change and wetland degradation shows that, in the Bondoukou test lowland, it is not easy to maintain the wet character of the lowland during the dry period because of the nature of the elements found there. In fact, the texture of the soil and the organisation of the elements occupying the space suggest the possibility of erosion, even to the point of localized forms of alteration, pedoplasty, oxidation and induration. This is mainly due to the lack of water during the summer, but above all to the almost total absence of mechanical weeding and reworking of the lowland soils.

Also, the conclusions of the work of Kutiel and Lukovic (2020) on the various aspects of drought in Serbia, certify that there is only a weak correlation between severity and regularity. Constancy measures the percentage of years in which a dry period of a given duration can be expected. It is also presented in the form of a return period [years], which is calculated as the inverse of the percentage. For example, Novi Sad and Negotin have both the highest severity and consistency values. In 10.2% of years in Novi Sad and 8.9% of years in Negotin, a dry spell of more than 30 days can be expected.

Similarly, investigations by Atidegla et al. (2017), on climate variability and rice production in the Bas-Fond de Dokomey in Benin reveal that 'all the producers in the study area stated that climate change contributes to crop failure and lower crop yields. The environment for plant growth and development has been severely disrupted in recent years, and is no longer conducive to good production'. In addition, authors have addressed the issue of lowlands in terms of crop diversification and improved nutrition. The work of Kaudjhis (2008) on inland valleys in west-central Côte d'Ivoire shows that market gardening initiated by women in rice-fish inland valleys is an interesting source of crop diversification. In Côte d'Ivoire, forestry is still a marginal activity compared to export farming. Cash crops alone account for more than 90% of cultivated land. In the Centre-West region, market gardening developed mainly around houses or on small areas of land that remained in the shadow of the plantation economy. The involvement of women in developing the lowlands has not only extended the area under these crops, but has also increased their availability. In the same vein, the conclusions of Souberou et al. (2018) on the geographical foundations of the development of the lowlands in the south of the Oti watershed in Benin confirm that this production diversification system is characterised by the use of traditional farming equipment, the type of agricultural labour, technical supervision and support provided by institutions and microfinance structures (agricultural credit). The cultivation techniques used by lowland farmers when preparing their fields are cleaning and storing crop residues on their farms (100% of respondents), grubbing up, burning trees and grass (when preparing fields for the first time or extending the area to be farmed) before ploughing. This information from the field survey showed that the development of lowlands in recent decades to produce a wide range of agricultural products is a response to a number of natural and human factors.

It can be seen that the issue of lowlands has been approached from the angles of climate change, climate variability, crop diversification and improved nutrition. Although previous authors have dealt with inland valleys, the issue of strengthening climatic resilience through their development in the rural commune of Bilanga, located in the eastern region of Burkina Faso, has not yet been studied on a local scale. To address this issue, the analysis involves taking into account not only climatic parameters such as rainfall, temperature, wind, insolation, relative humidity and evapotranspiration, but also farmers' perceptions of climatic variability and the importance of lowlands to the farming community. The interaction between these elements sheds light on the essence of an agrosystem, thus justifying the use of a systems approach in this research.

Geographical context

The rural commune of Bilanga lies in the south of the province of Gnagna, of which it is one of seven communes. It is 52 km from Bogandé, the provincial capital of Gnagna, and 75 km from Fada N'Gourma, the regional capital in the east, which is accessible by national road no. 18. It has a dry tropical climate, with alternating dry and rainy seasons. Hydrographically, it is made up of temporary watercourses, including the Sirba, the main river, and the Sidi-Kompienga, its main tributary. This network is completed by a multitude of permanent or temporary pools and marshes in the lowlands. They play an important role in the agro-slvo-pastoral life of the rural commune of Bilanga in a context of climatic variability.

Methodological framework

The methodological approach adopted is based on quantitative and qualitative data derived from documentary analysis, interviews and questionnaire surveys. Documentary research consisted of analysing information on climate variability and the use of inland valleys in articles, dissertations, theses, books and reports consulted in ministries and development organisations, in university libraries, in research structures and on the Internet. The field surveys took place in 2024. They were based on the commune's territorial organisation. Three localities: Bilanga, Dipienga and Moaka (figure 1) were surveyed.

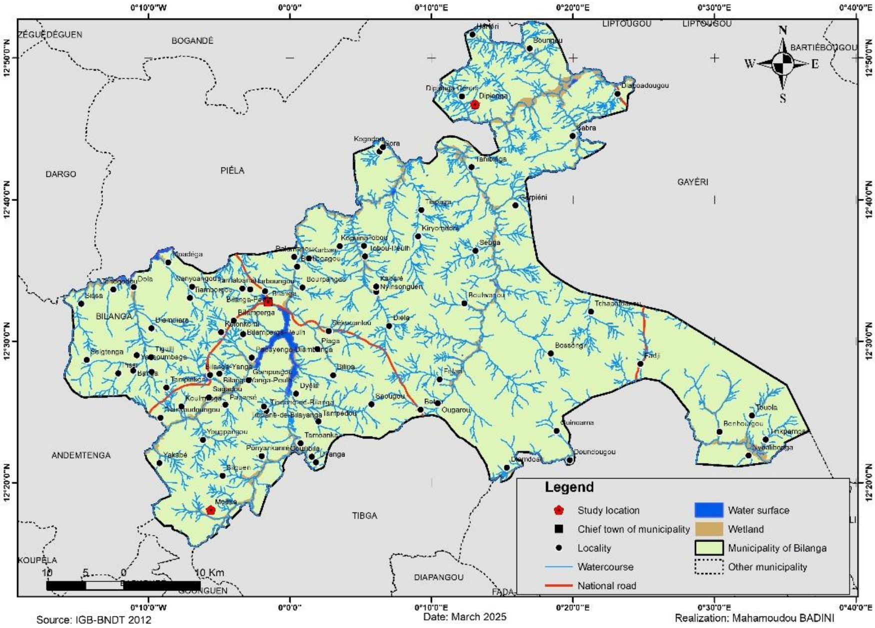

Fig. 1. Locations surveyed in the field

These areas were selected on a reasoned basis. Farmers were selected for the surveys on the basis of two criteria: they had to be the head of a lowland farming household living in the area, and they had to be at least 30 years old in order to be able to answer the questions on climate variability. It was necessary to select standard samples, with 35 heads of household surveyed per locality, regardless of the size of the target population in each locality (Table 1).

Table 1. Breakdown of households by location surveyed

Localities	Number of population in 2016	Number of households	Sample sample retained	Corresponding rate (%)
Bilanga	3 893	605	35	5,78
Dipienga	1068	168	35	20,83
Moaka	5561	732	35	4,78
Total/Average average	12 430	1505	105	6,97

Sources: INSD, 2019 and author's calculations in 2025

A total of 105 lowland farmer heads of household were surveyed out of a target population of 1,505 households, giving an overall sampling rate of 6.97%. The field investigations took place over three months (April, May and June 2024). Qualitative surveys were conducted with the heads of the decentralised government departments: the head of the agricultural technical support zone (ZATA) and the head of the livestock technical support zone (ZATE). In addition, rainfall, temperature, relative humidity, insolation and wind data from 1994 to 2023 from the Fada N'Gourma station were collected from ANAM. This station was chosen because it covers the study area and has all the data relating to the climatic parameters listed. Similarly, the analysis of interannual rainfall variability was carried out using reduced standardised anomalies. These anomalies were calculated using the formula for analysing the interannual variability of the following indices:

$$x_i' = \frac{x_i - \bar{x}}{\sigma(x)} \quad (1)$$

where:

x_i' = centred reduced anomaly for year i
x_i = the value of the variable;
$\bar{x}$= the mean of the series.
σ(x)= the standard deviation of the series

Furthermore, in order to characterise the level of drought severity in the rural commune of Bilanga, the calculation of the Standardised Precipitation Index (SPI) for the study period (1994-2023) is of paramount importance. In the Sahel in general, and Burkina Faso in particular, the Standardised Precipitation Index (SPI) is used to determine whether a year is wet or dry. This index is recommended by a number of organisations, including the World Meteorological Organisation (WMO) and the US National Oceanic and Atmospheric Administration (NOAA). In 2009, the WMO adopted the Standard Precipitation Index (SPI) as the instrument for measuring meteorological droughts, under the terms of the 'Lincoln Declaration on Drought Indices'.

Results

Climate variability: a scientific vision in line with farmers' perceptions

Climatic variability in the rural commune of Bilanga is characterised by wide inter-annual variations in rainfall. Rainfall trends over the last thirty years (1994-2023) show that rainfall varies from year to year (figure 2).

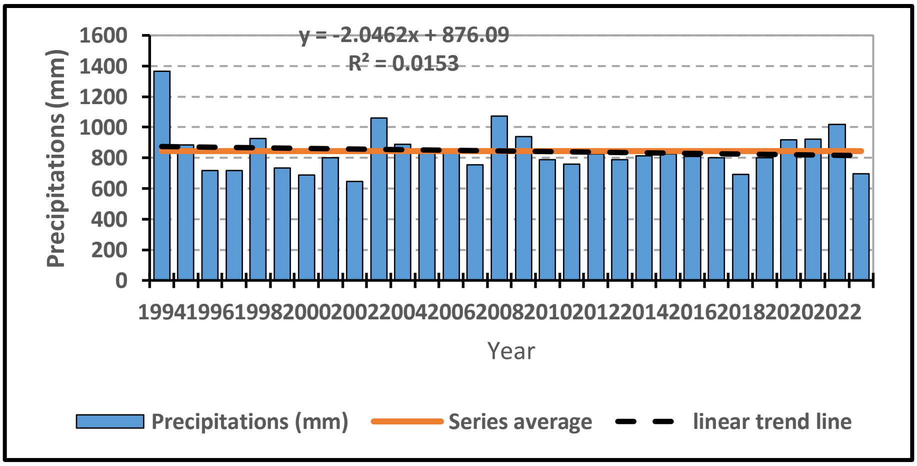

Fig. 2. Interannual rainfall trends

This inter-annual variability in rainfall is marked by the alternation of wet years (33% in 1994, 1995, 1998, 2003, 2004, 2008, 2009, 2020, 2021 and 2023), as the average rainfall is greater than 844mm, which is the average for the series, and 67% of deficit years. An intense variation in rainfall can be observed in the years 1994, 2003, 2008 and 2022, which mark rainy years with rainfall in excess of 1000mm. On the other hand, the years 2000, 2002, 2018 and 2023 have low rainfall with P<700mm. In short, this variation in rainfall is confirmed by the linear regression and its directing coefficient (-2.0462). The very low coefficient of determination (R^2 =0.0153) shows that there is a high probability that this trend will continue over time.

Analysis of changes in the standardised rainfall index (SRI) over the period from 1994 to 2023 (figure 3) will therefore enable us to better define the dry years.

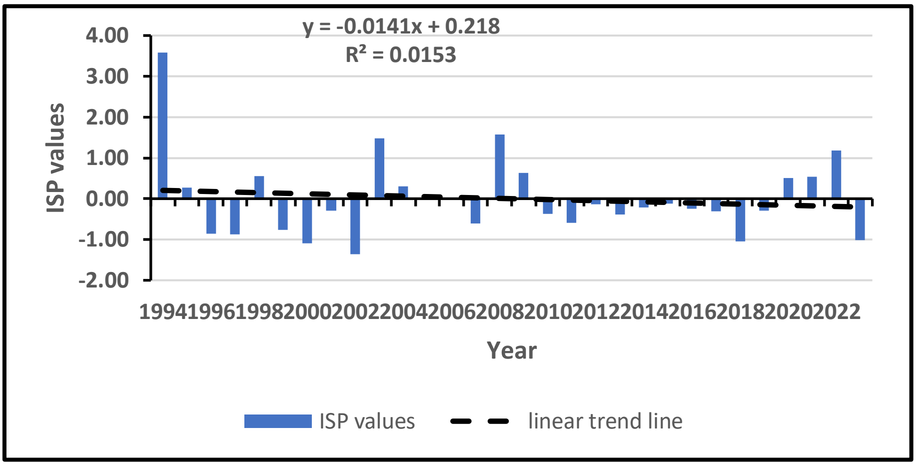

Fig. 3. Change in the standardised precipitation index

Over the analysis period, the PSI shows alternating dry and wet years, with a downward trend as indicated by the trend line. The very dry years are characterised by major rainfall deficits for agricultural activities. There are four such years (-1 ≤ISP≤ -1.36): 2000, 2002, 2018 and 2023. There are sixteen moderately dry years (-1.36 ≤ PSI ≤ -0.02), namely 1996, 1997, 1999, 2001, 2005, 2006, 2007, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017 and 2019. There are six moderately wet years (0 ≤ PSI ≤ 1), namely 1995, 1998, 2004, 2009, 2020 and 2021, and four wet years characterised by excess rainfall (1.19 ≤ PSI ≤ 3.59), namely 1994, 2003, 2008 and 2022. Moreover, analysis of the PSI reveals that over the 30 years analysed, there are 10 wet years and 20 dry years, which will prompt the Bilanga farming community to focus on developing the lowlands in order to adapt to the inter-annual variability in rainfall. Another parameter of climatic variability in the rural commune of Bilanga is the high interannual variability of its mean annual temperatures (figure 4).

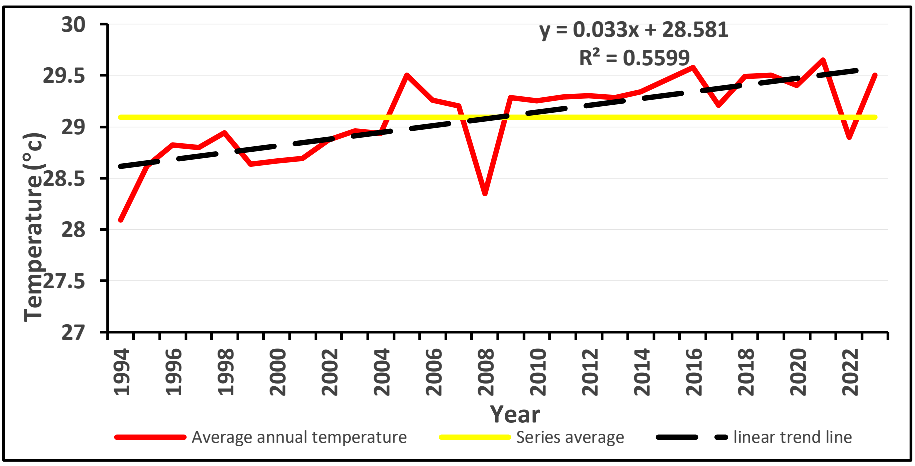

Fig. 4. Year-on-year change in mean annual temperatures

The average temperature rose from 28.09°C to 29.50°C between 1994 and 2023, a difference of 1.41°C. This rise in temperature is recorded in the years 2005, 2006, 2007, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021 and 2023, whose temperatures are higher than the average (29.09¨C) for the series. On the other hand, 2021 is the hottest year with 29.65°C. This rise in temperature in the rural commune of Bilanga is confirmed by the linear regression and its correlation coefficient R^2 = 0.5599. Relative humidity is one of the climate parameters that can be used to forecast the weather. Humidity fluctuates with the seasons and is a function of wind patterns and associated air masses. In the rural commune of Bilanga, relative humidity (figure 5) from 1993 to 2023 is characterised by interannual spatial variation.

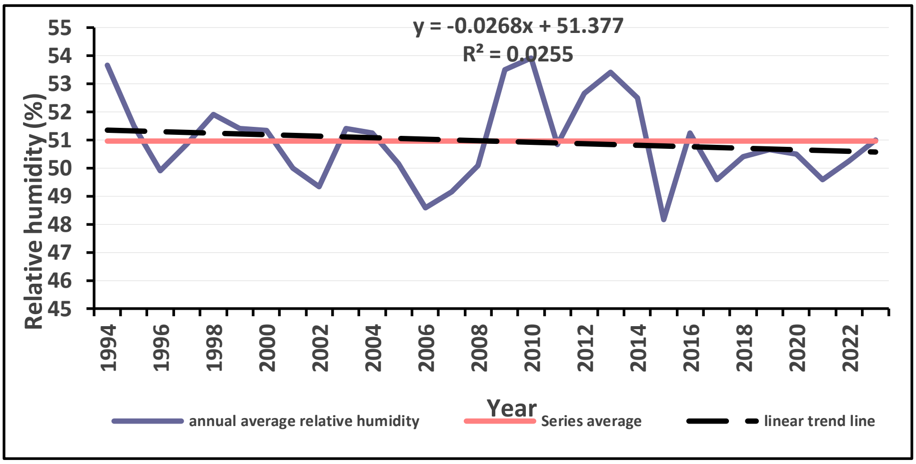

Fig. 5. Interannual variation in relative humidity

An analysis of the annual change in relative humidity in Figure 4 reveals inter-annual variation in humidity values, in the same way as rainfall and temperature.

The lowest average annual humidity was recorded in 2015, at 48.16%, and the highest in 2010, at 53.91%. The trend line for average annual relative humidity shows a downward trend. This decrease in humidity may therefore compromise the sustainability of agricultural activities in the study area.

Taking seasonal trends into account, humidity is higher in the rainy season. Over the period from 1994 to 2023, the months of June, July, August and September have a rate of over 65% (figure 6).

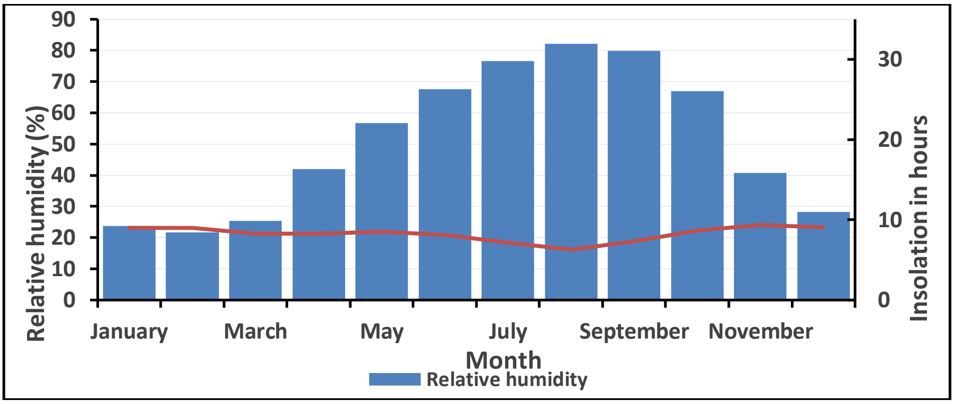

Fig. 6. Changes in average monthly relative humidity and insolation at the synoptic station from 1993 to 2023

During the dry season, air humidity remains below 42%, with February showing the lowest level at 21.77%. Relative humidity is an essential climatic factor for off-season activities, which are booming in the region studied.

Sunshine is the period, measured in hours or fractions of an hour, during which the sun is visible. The lowest values were recorded between June and September, with an average of less than 8 hours per day over the period 1993 to 2023. The average annual sunshine duration in the study area is 8.56 hours. The highest levels of insolation are observed in the dry season (November to May), with November showing the maximum peak of 9.35 hours. Figure 7 shows the inter-annual variation in insolation.

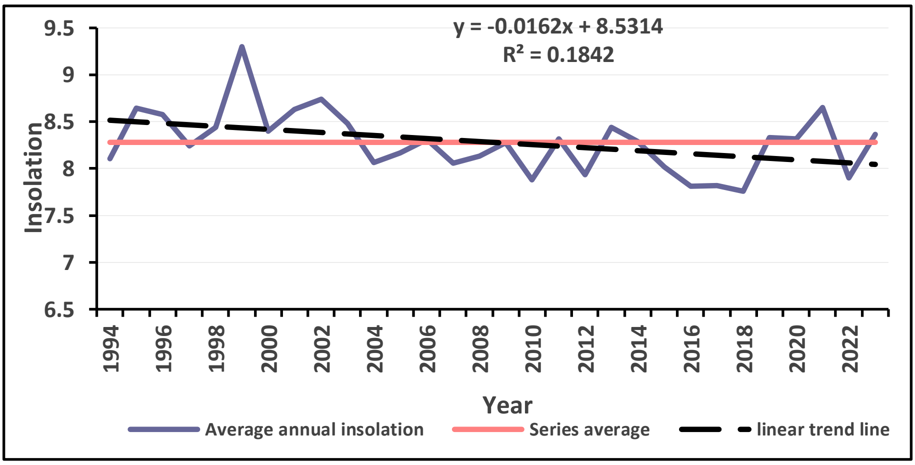

Fig. 7. Interannual changes in insolation

Analysis of Figure 5 shows that of the 30 years, sixteen (1995, 1996, 1998, 1999, 2000, 2001, 2002, 2003, 2006, 2011, 2013, 2014, 2019, 2020, 2021 and 2023), or 53.33%, have insolation above 8.27 hours, which is the average for the series. In general, the insolation data for the study area show a downward trend, as indicated by the linear regression line.

In addition to relative humidity and insolation, wind plays an important role during agricultural campaigns. In fact, the trend line for average annual wind speeds shows a general increase from 1993 to 2023 (figure 8).

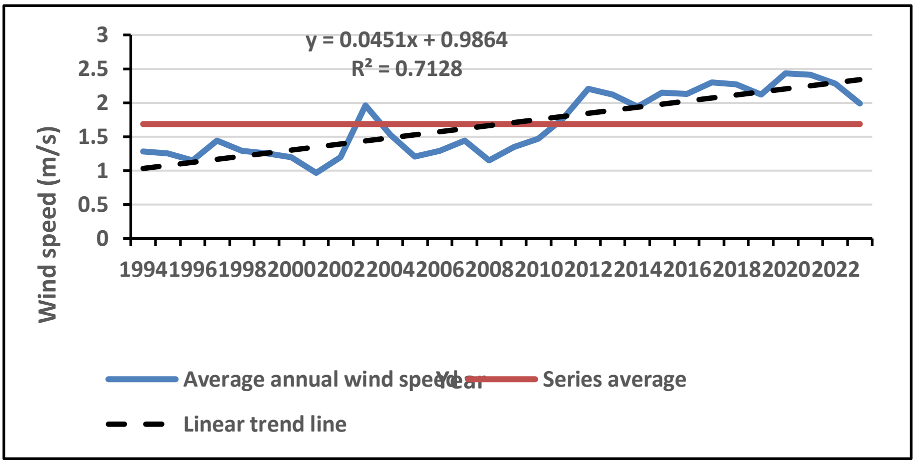

Fig. 8. Interannual change in wind speed

It shows strong inter-annual variation in wind speed. This has an impact on activities, as the study area is devoid of natural obstacles.

By way of summary of the analysis of the evolution of climatic factors, it should be noted that there has been an increase in temperature and variability in rainfall, accentuated by extreme values. A downward trend in relative humidity, sunshine and an increase in wind speed.

In addition to the scientific findings, the communities in the study area also have their own perceptions of the climate, based on its visible effects and the impact it has on their activities. For example, family farmers in the rural commune of Bilanga perceive climate change and variability in terms of falling rainfall. 97.26% of farmers say that it does not rain as much as it used to. They stress the irregular nature of this rainfall. To better understand the reasons for this general perception of reduced rainfall in the study area, the stakeholders went beyond simply counting rainy days to consider other aspects. This drop in rainfall was attributed by 55.6% of respondents to a premature end to the rains, while 30.8% mentioned the high frequency of dry spells during the rainy season. A further 10.6% pointed to a delay in the start of the rainy season, while 3% mentioned the low volumes of water brought down by rainfall. When asked whether there were periods of drought during the rainy season, 98.11% of respondents said there were. Of these, 90.15% felt that these dry spells are now much more frequent than they were in the past. Furthermore, 77.89% believe that these interruptions to rainfall, which occur at the height of the rainy season, can last between one and two weeks. This phenomenon is mainly observed during the months of June and July.

From an environmental point of view, 96.88% of stakeholders consider that the main effect of rainfall variability lies in the transformation of the appearance of the plant cover. This change can be seen in the gradual disappearance of certain plant species, the clearing of formerly densely wooded ecosystems, and a significant decline in biodiversity.

Farmers' perceptions of temperature and sunshine are reflected in a general impression of ambient heat. According to 89.97% of respondents, the intensity of the sun's rays has increased over the last fifteen years, which logically leads to an increase in the heat felt. This heat, which is omnipresent throughout the year, is considered overwhelming in the dry season by 77.45% of respondents, and suffocating during the rainy season.

Winds are also mentioned as markers of the climate variability observed in recent years. According to the various stakeholders consulted, winds have changed in terms of intensity and frequency. This transformation is attributed to current environmental conditions. For example, 83.98% of family farmers in the rural commune of Bilanga consider that their agricultural plots are exposed to the wind, whether during the wet or dry season. This situation compromises production by causing crop lodging and complicating plot maintenance.

There is a correlation between local perceptions and scientific analyses of climatic parameters. As far as the wind is concerned, its intensity is associated with the deterioration of the plant cover. This deterioration amplifies wind erosion phenomena, which could explain the increase in dust particles in suspension, as well as the increase in wind strength and its effects. The rise in temperatures, combined with the fall in rainfall, foreshadows the intensity of extreme weather events in the rural commune of Bilanga. Faced with this situation, stakeholders are inevitably reacting to optimise the use of resources, which explains the development and use of low-lying areas.

Lowland farming: a lever for climate resilience in the farming community of Bilanga

Lowland development is a strategy for strengthening climate resilience in the rural commune of Bilanga. The scientific view of climate variability and farmers' perceptions show that the study area is characterised by irregular rainfall, frequent droughts (twenty years in the analysis series), rising temperatures and wind speeds, falling relative humidity and sunshine, all of which make traditional agriculture more precarious. As wetlands, lowlands play an essential role in managing water resources and soil fertility. They maintain residual moisture and provide favourable conditions for agriculture, even in periods of drought. For family farmers, the use of inland valleys is seen as a key lever for strengthening the climate resilience of farming communities. Figure 9 shows the main reasons for this strategy:

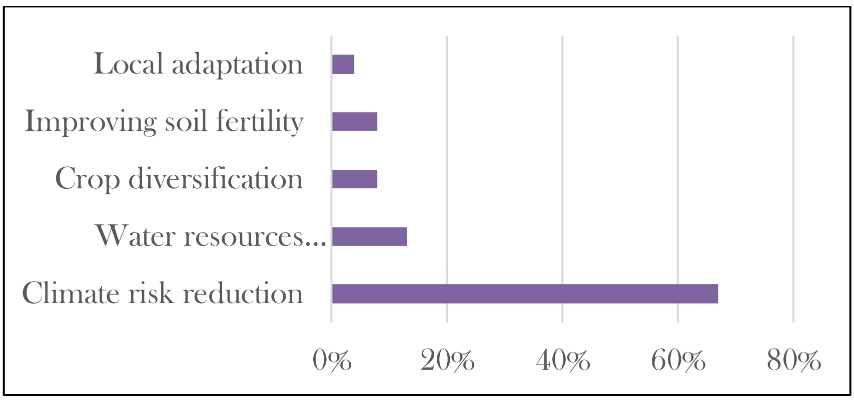

Fig. 9. Reasons for developing lowlands as climate resilience

The data in the figure call for the following analyses:

- 67% of family farmers in the rural commune of Bilanga say that lowland farming helps to reduce climatic risks: in the event of drought or climatic variability, lowlands act as buffer zones, offering rural communities a degree of stability. There are two types of inland valley in the study area: undeveloped and developed. Undeveloped lowlands are used only during the rainy season for cereal crops (white sorghum (Sorghumguineensis), millet (Pennisetumnigritarum)) in the upstream part. The downstream part, on the other hand, is used for grazing. According to the head of the agricultural technical support zone (ZATE) in the rural commune of Bilanga, the developed lowlands cover an area of 468 hectares, spread over seventeen villages. In addition, the total potential of developable land is estimated at more than 1,000 hectares. Field surveys revealed that all the villages in the rural commune of Bilanga have at least two lowlands, due to the general orientation of the drainage, which follows a very gentle north-west/south-east slope. Family farmers are unanimous that the lowlands represent attractive areas for stable and varied farming. As a result, they have gradually been transformed into prime areas for emerging commercial agriculture, due to the recognition of their protective role against climatic hazards, particularly droughts that compromise rainfall-dependent crops. Farmers in the study area recognise that water management in flood-prone areas, combined with the interactions between various physical, agronomic and social elements, gives these areas a character that is both unique and complex. This particularity gives rise to challenges linked to the control of water resources and the optimisation of their agricultural use.

- 13% of farmers confirm that inland valleys help to manage water resources in a context of climate variability. In fact, lowlands retain water for longer periods, enabling irrigated agriculture and reducing dependence on irregular rainfall, a common problem in areas affected by climate change such as the commune of Bilanga. Farmers claim that, thanks to their high water reserves, abundance of organic matter and nitrogen content in the top layer of clay soils, these environments are ideal for growing crops that require heavy irrigation, such as rice, as well as long-cycle crops such as sorghum.

- 8% of farmers show the importance of the lowlands in agricultural diversification. Farmers were unanimous in saying that using the lowlands enabled them to grow market garden crops during the dry season. These crops include onions, tomatoes, lettuce, aubergines, green beans, cabbages, carrots and maize. The sale of these vegetable crops provides substantial income for producers, helping to improve their living conditions and those of their households. During the rainy season, the predominant crops grown in the lowlands are white sorghum, millet and rice.

- 8% of lowland farmers in the study area say that they help to improve soil fertility, as these areas benefit from alluvial or colluvial inputs that naturally enrich the soil, thereby promoting more sustainable agricultural production. Waterlogged, sandy-clay soils are found in depressions close to watercourses. More compact and deeper, they require specific tillage methods and adapted equipment, different from that used on other plots. The crops grown here offer greater nutritional and economic value than conventional cereals, particularly rice, manioc, sweet potatoes, taro, maize and onions.

- 4% of farmers believe that the lowlands contribute to local adaptation. The farming communities of Bilanga have developed specific approaches to exploiting these areas, taking account of local realities and environmental constraints. These approaches include crop associations and crop rotation. They also involve the development of large mounds arranged parallel to the flow of water to encourage its drainage, while others are placed perpendicularly upstream and downstream of the first series. Together, these create adjustable obstacles that make it easier to regulate the water level between the mounds.

Discussion

Analysis of changes in climatic factors shows an increase in temperature and variability in rainfall, accentuated by extreme values. A downward trend in relative humidity, sunshine and an increase in wind speed. These results are shared by the work of Burić et al. (2018). In fact, these authors carried out calculations at annual level for mean, mean maximum and mean minimum temperatures, as well as for precipitation sums. The results obtained for the three temperature parameters, the maximum values in particular, show that the 1981-2010 period was significantly warmer than the previous three decades. These scientific conclusions are in line with farmers' perceptions. These results are similar to those of Yaméogo (2023). The author indicates that pockets of drought, heavy rainfall and the shortening of the rainy period lead to the death of seedlings and stunted growth of young shea shoots.

Temperature and wind have a greater impact on flowering, fruit set and fruit set. Similarly, the results of Ilboudo's research (2023) confirm that farmers have a negative perception of rainfall, which they fear will result in a reduction in the amount of water precipitated, a late start, an early end, an increase in periods of drought and flooding, etc. In some cases, these fears coincide with the scientific analyses carried out. In some cases, these fears coincide with scientific analyses. Indeed, the work of Milošević et al. (2020) shows that this is mainly the consequence of the different insolation/shading patterns of the individual measurement sites during the day. During the night, we noticed that tropical nights are more frequent in the medium-height LCZs, followed by the low-height LCZs. This is a problem for the population of Novi Sad who live mainly in these areas and whose health and leisure activities are affected by the thermal conditions observed. The surveys conducted by Ouédraogo (2024) also show that the local perception of rural populations in the commune of Korsimoro highlights several major trends concerning climate dynamics. Firstly, they note a random distribution of rainfall and an increase in droughts over the years. These prolonged droughts reduce the availability of water for irrigation and domestic needs, leading to lower agricultural yields and increased food insecurity. Rural populations are also noticing variations in rainfall patterns, with shorter rainy seasons and more intense and unpredictable rainfall, which can lead to flash floods and crop losses. In the same vein, the work of Kutiel and Lukovic (2020) shows that in Serbia , agricultural land occupies 70% (57,340 km2) of the total surface area. It is highly dependent on rainfall. The greatest severity of drought occurs in the northern and eastern parts of Serbia, with consequences for agricultural production.

This research has shown the importance of inland valleys in the face of climate variability. The investigations revealed that the use of lowlands is a lever for climate resilience in the community of Bilanga. Our findings are similar to those of Zaré (2015). The author shows that the climatic issues involved in the use of inland valleys are of great concern and that 'in order to reduce the vulnerability of production systems to climate variability, it is therefore necessary to mitigate the impacts of irregular flooding, rainfall and flooding, and to reduce climate risk. This means securing and controlling water on the one hand, and anticipating and adjusting production techniques with the help of climate forecasting on the other. In the same vein, the findings of Adou et al. (2024) confirm that farmers have adopted strategies to improve production and yields in the Gazibouo lowland in the face of increasingly recurrent constraints linked to climate change. These strategies involve both taking into account the cropping calendar and agricultural production techniques. Moreover, the conclusions of the research by Bassolé et al. (2023) are contrary to our results. The authors state that the ferruginous leached soils on the site (FLIS, FLIPP and FLC) have a shallow useful depth, a very hard to extremely hard consistency and a coarse texture (silty-sandy). They have very low usable water reserves and gravelly fillings consisting of ferro-manganese gravel. These morphological characteristics are not conducive to crop development. Tropical brown eutrophic soils, on the other hand, generally have characteristics that are favourable to crops.

Conclusion

This manuscript analysed the strengthening of climatic resilience through the development of lowlands in the rural commune of Bilanga, in the eastern region of Burkina Faso. Over the period from 1994 to 2023, the research results showed rising temperatures, variability in rainfall accentuated by extreme values, a downward trend in relative humidity and insolation, and an increase in wind speed. These scientific findings are in line with farmers' perceptions of climate variability. The conclusions of this research also showed that the development of lowlands by family farmers in the rural commune of Bilanga is a real lever for strengthening climate resilience. In fact, the use of inland valleys helps to reduce climatic risks, control the management of water resources, encourage diversification of agricultural production or crops, improve soil fertility and facilitate local adaptation to climate change. All of which helps to improve people's living conditions. Producers are unanimous in saying that exploiting the lowlands enables them to be self-sufficient, and they sell the surplus for cash. The rural commune of Bilanga is an area with high lowland potential, and it would be a good idea to develop all the undeveloped lowlands to help farmers in this commune become self-sufficient in terms of food and finance.

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