ESJ Humanities

Constraints and Prospects of rice Production in a Climate Change Context in the Sissili Province, Burkina Faso

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Doi:10.19044/esj.2022.v18n23p140

Submitted: 19 March 2022
Accepted: 27 July 2022
Published: 31 July 2022

Cite As:
Sanou K. & Dipama J.M. (2022). *Constraints and Prospects of rice Production in a Climate Change Context in the Sissili Province, Burkina Faso*. European Scientific Journal, ESJ, 18 (23), 140. https://doi.org/10.19044/esj.2022.v18n23p140

Abstract

In terms of irrigated agricultural production in Burkina Faso, rice is the second most important crop after maize. This rice production is supposed to satisfy domestic demand and reduce imports, which has an impact on the country's trade balance. However, the rice sector is faced with climatic and technical productivity constraints. Indeed, the variability of temperatures and rainfall over the period 1988-2018, with its corollaries of drought and flooding episodes, has an impact on agricultural activity. The objective of this study is to analyze the effect of the dynamics of climatic parameters as well as the effectiveness of technological packages on rice productivity in Sissili Province. To this end, a methodology based on the quantitative approach was adopted. It is based on the collection, processing, and analysis of numerical data on key climatic parameters from the Pô synoptic station from 1988 to 2018. These data were correlated with those available on rice production over the same period. The analyses show that Sissili Province is marked by alternating rainfall deficits and surpluses, which have an impact on rice production, the evolution of which is out of phase with the increase in planted areas. This suggests that increasing the area planted seems to be an alternative way of compensating for a possible drop in rainfall. Under these conditions,

ISSN: 1857-7881 (Print) e - ISSN 1857-7431

the development of lowlands and water reservoirs represents opportunities for the diversification of production systems.

Keywords: Rice cultivation, Contraints, Climat, Sissili, Burkina Faso

Introduction

Burkina Faso is an agricultural country that is highly dependent on its often deficient rainfall. Thus, the dams that dot the country play an important role in agricultural production and food security. Investments in agricultural production, and more specifically in rice production, can be seen in the development of lowlands and irrigated areas downstream from dams (Dare and al., 2019). The country's development potential is estimated at more than 500,000 ha of lowlands and actual development is around 10,208 ha (Agreer-Statistica, 2006). Rice is the second most important cereal crop in irrigated production after maize, and fourth after millet, sorghum, and maize in rainfed production. It is therefore called upon to meet the country's domestic demand to reduce its dependence on imports, estimated at 40 billion *CFA francs* in 2008 (Dama-Balima, 2013). However, this rice production is confronted with variability in temperature and rainfall, management, and production techniques that hinder its productivity. This intra- and inter-annual variability in rainfall, punctuated by episodes of drought and flooding, has become recurrent over the period 1988-2018 and influences agricultural activity.

To learn more about the dynamics of rice production in the face of climate variability, the following question is asked: how does climate variation influence rice production? The present study aims to analyze the effect of changes in the frequency and intensity of climatic parameters on rice productivity. The province of Sissili, located in the *''Centre-Ouest''* region of Burkina Faso, is an illustrative case.

Study zone

The *''Centre-Ouest''* region of Burkina Faso is located between 11° and 12° 50' north latitude, and 1° 20' and 2° 55' west longitude. This region contain four provinces : Boulkiemdé, Sanguié, Sissili and Ziro. It is characterized by a North Sudanian climate (Figure 1), while the Sissili province belongs mainly to the North Sudanian zone, marked by the 800 mm isohyet. Over the observation series (1988-2018), the Pô synoptic station indicates a rainfall ranging from 728 mm to 1,290 mm with an average of 1,024 mm which is well above the national average (750 mm).

The area is drained by the *Mouhoun* and *Nakambé* rivers. Agriculture is the main economic activity, supported by sedentary livestock with a herd essentially consisting of small ruminants.

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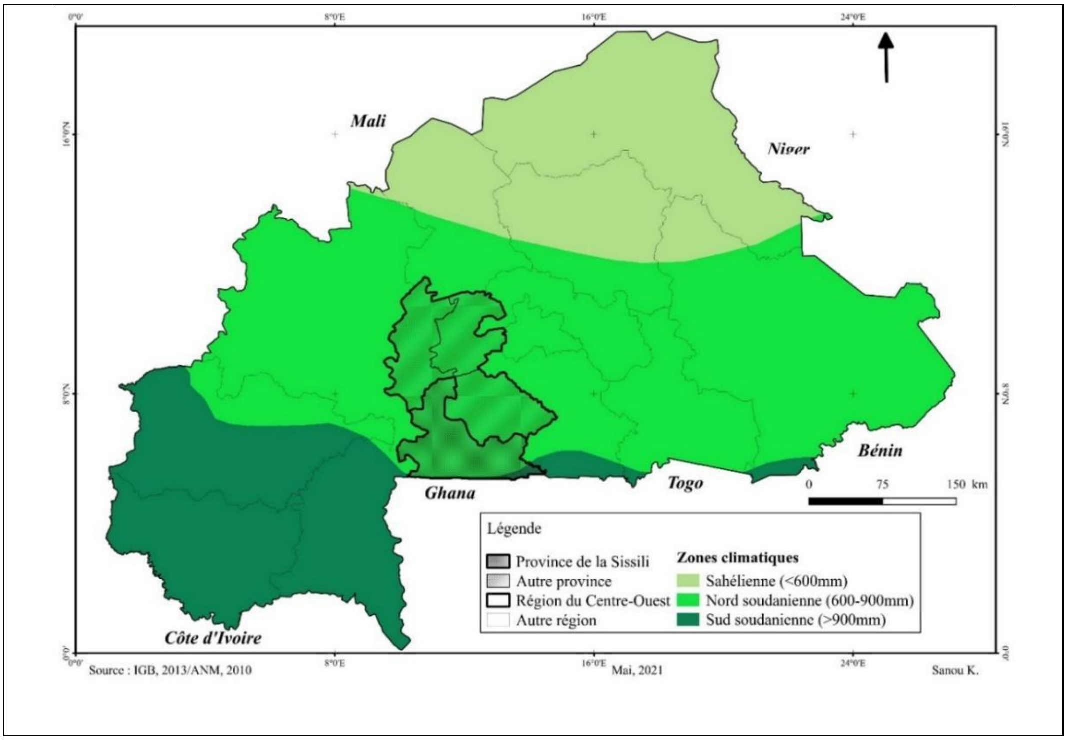

Figure 1: *''Centre-Ouest''* region in relation to the climatic zones of Burkina Faso

Agricultural production consists of food crops (sorghum, millet, corn, and rice), cash crops (cotton), and irrigated crops (rice and vegetables). In addition to the highlands, the areas around dams and inland valleys are increasingly used for dry season crops. Sissili province is naturally endowed with floodplain/lowlands (Figure 2).

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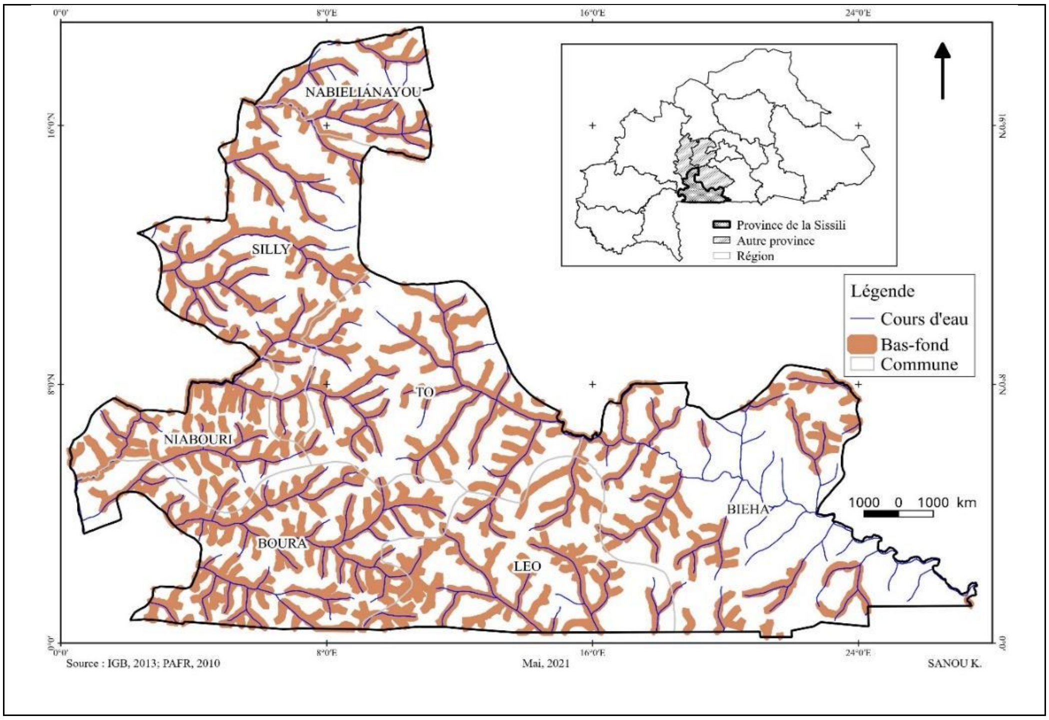

Figure 2: The lowlands in the province of Sissili

These rice plains are sometimes developed by projects (sponsored by non-governmental organizations) or programs in collaboration with the Regional and Provincial Directorates of Agriculture. These are the program for the development of lowlands in the South West and Sissili (PABSO), the rainfed rice project (PRP), the action plan for the rice sector (PAFR), the national land management program 2nd phase (PNGT2), the micro-dam action (AMB), the project agricultural intensification through water management in the South-West and Centre-West (PIAME/SOCO), the small-scale village irrigation development project (PDPIV), the small-scale irrigation and water management project (PIGEPE), the food security and productivity improvement program (PAPSA).

The latter intervene without any consultation and coordination of activities carried out in the field, yet they are all specialized in the development and rehabilitation of perimeters and lowlands for the benefit of the community. Thus, the region's developable potential is estimated at 4,073 ha, of which 1,339 ha are developed over areas ranging from 1 to 30 ha for 88.4 % of the lowlands (Dama-Balima, 2013). Of the four provinces in the region, Sissili province, which is the least endowed with developable potential (789 ha), has 386 ha developed, or 28.8 % of the region's developments, which are exploited throughout the year. These areas are primarily used for rice cultivation and market gardening in the off-season.

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Data and Methods

Data

Climatological series (rainfall and temperature) from the Pô synoptic station, from 1988 to 2018, are collected from the National Meteorological Agency. Rice production data for Sissili province are extracted from the file of the Directorate of Agricultural Statistics of the Ministry of Agriculture to analyze the evolution of rice production from 1988 to 2018 concerning the variation of climatic parameters. Finally, a survey of farmers is conducted on production constraints, strategies, and crop use.

Methods

The quantitative approach was adopted. The evolution of rainfall is characterized by Standardized Precipitation Indices (SPI) which is a centered reduced value of annual rainfall. The calculation of the SPI makes it possible to determine the degree of dryness or moisture of the environment (Mc Kee and *al.*, 1993; Bergaoui and Alouini, 2001). The value of the SPI is between -2 and 2.

When SPI < -2, we have a case of extreme dryness;
if -2<SPI< -1, we have a strong drought;
and if -1<SPI< 0, we have moderate dryness;
for 0<SPI< 1, we have moderate humidity;
for 1<SPI<2, we have strong moisture;
for SPI > 2, we have a case of extreme humidity.

Rainfall data were correlated with rice production data to detect the presence of a linear relationship. To do this, XLSTAT software was used for linear regression to identify the coefficient of determination and Pearson correlation test. A questionnaire was sent to 120 rice farmers and 6 interviews were conducted with agents of the technical services of agriculture. The information obtained from these exchanges allowed us to better understand cultivation practices and the influence of rainfall on rice production.

Results

Evolution of rainfall and temperature

The Sissili province is marked by interannual variation in rainfall. This is reflected in alternating rainfall deficits and surpluses (Figure 3).

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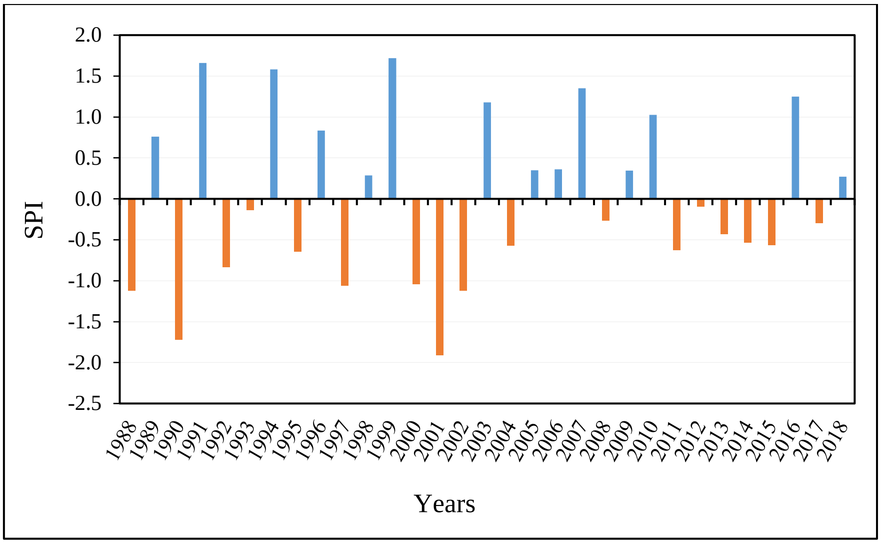

Figure 3: Interannual variation of precipitation of the Po synoptic station (1988 to 2018)
Source: National Meteorological Agency (Burkina Faso)

The most significant surplus years are 1991, 1994, 1999, 2003, 2007, 2010, and 2016 with an SPI of 1.72 for the wettest year in 1999. Thus, for the entire series (1988-2018), the province has not recorded any extreme wet years, which reduces the risk of severe flooding that would prohibit tillage during the plowing season.

As for the rainfall deficits, which are periods of severe drought, they concern the years 1988, 1990, 1997, 2000, 2001, and 2002, where the SPI is between -1.04 (2000) and -1.91 (2001). Over the observation period, the province has experienced six years of severe drought, including three consecutive years (2000-2002). It is also worth noting five successive years of moderate drought (2011-2015). This episode of the moderate drought of 3 to 5 years reoriented cultivation practices, both in terms of techniques and in the choice of crops.

On the other hand, the analysis of temperatures recorded at the Pô station shows an irregularity in its evolution (Figure 4). The maximum temperature, 28.9°C, was reached in 2015, a year qualified as moderate drought. As for the minimum temperature, it was 27.7°C, recorded in 1989, corresponding to a year of relative humidity.

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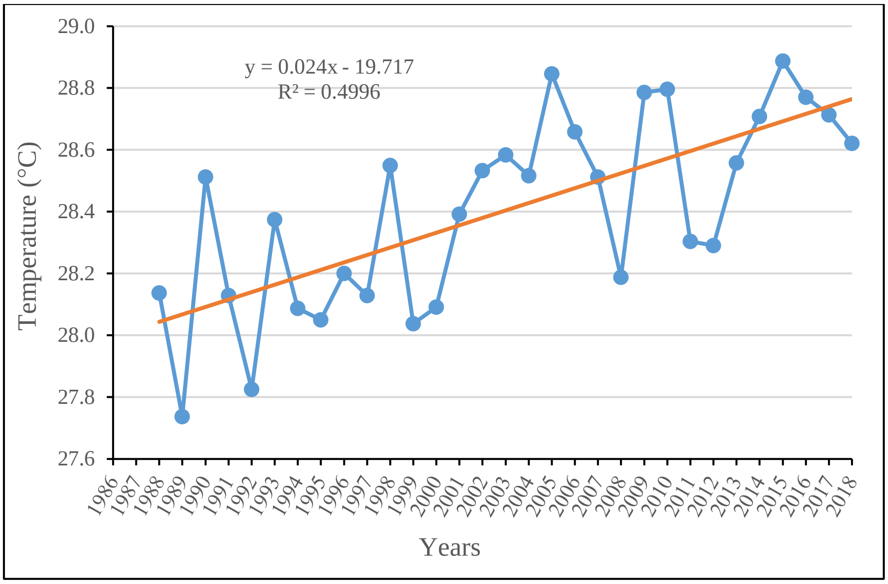

Figure 4: Variation in average annual temperatures from 1988 to 2018
Source: National Meteorological Agency (Burkina Faso)

The annual average of the series is 28.4°C with a deviation of +1.2°C which reflects an increase in temperature represented by the trend line and confirmed by a positive director (0.024).

This variability in rainfall and temperature, punctuated by dry spells, affects yields and promotes food insecurity, which can lead to socio-economic crises. What about the three decades (1988-2018) with an appreciation of monthly averages (Figure 5) ?

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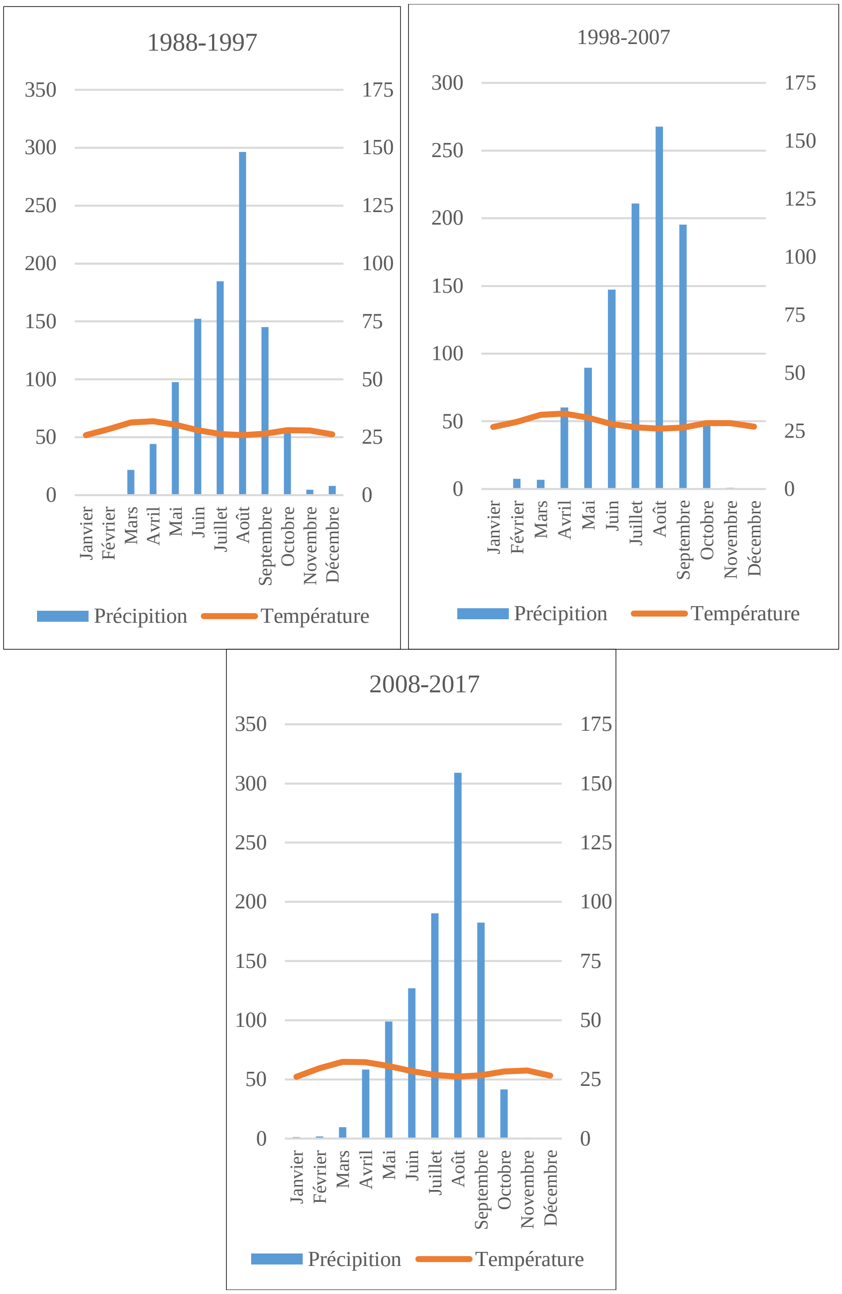

Figure 5: Decadal umbrothermal curves of the Po synoptic station
Source: National Meteorological Agency (Burkina Faso)

From the analysis of figure 5, it appears that the seasonal evolution of rainfall is almost the same over the three decades. The wet periods are spread over six months for the first two decades and over five months for the last, with the maximum rainfall recorded in August. The onset of the rainy season

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

is not very variable (April-May), but this analysis could hide periods of early or late-onset. The end of the rainy season is less variable and is generally in October for the observation series.

Evolution of rice production

Figure 6 shows the relationship between changes in annual production and the area planted in Sissili province. Examination of the curves reveals a general sawtooth pattern. The evolution of rice production is irregular, compared to the areas planted, which show a sustained increase over the years 1994-1998 and 2011-2015.

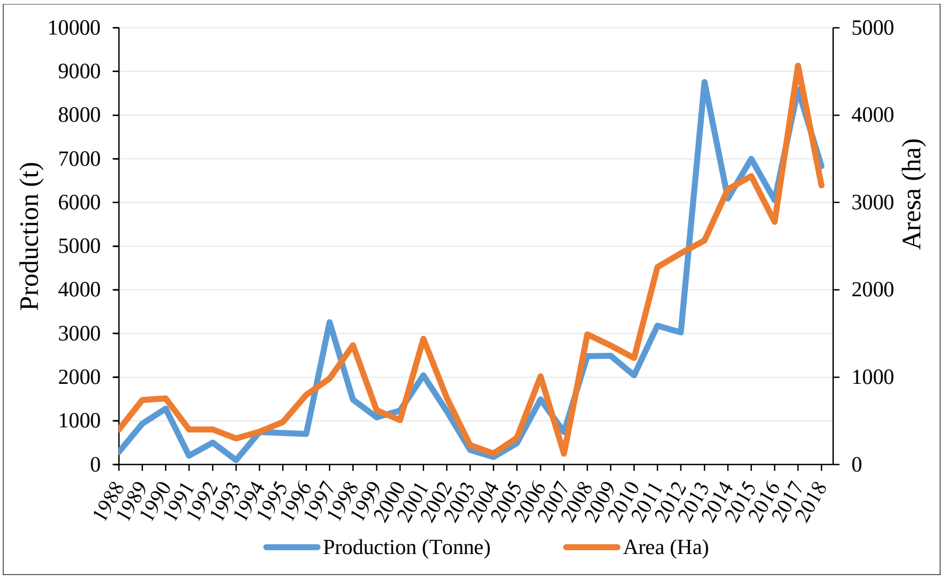

Figure 6: Annual change in rice production and area from 1988 to 2018
Source: Directorate of Agricultural Statistics of the Ministry of Agriculture (Burkina Faso)

The first phase of the increase in sown area over five consecutive years followed two years of rainfall deficit (1992-1993) and the second, most marked phase corresponds to an episode of moderate drought (Figure 3). The upward trend in the planted areas appears to be a strategy for dealing with a possible decline in rainfall. Indeed, the correlation between rice production, area, and rainfall data indicates a link (Figure 7). The coefficient of determination (R^2) is 0.87 for rice production and the area planted (Figure 7a).

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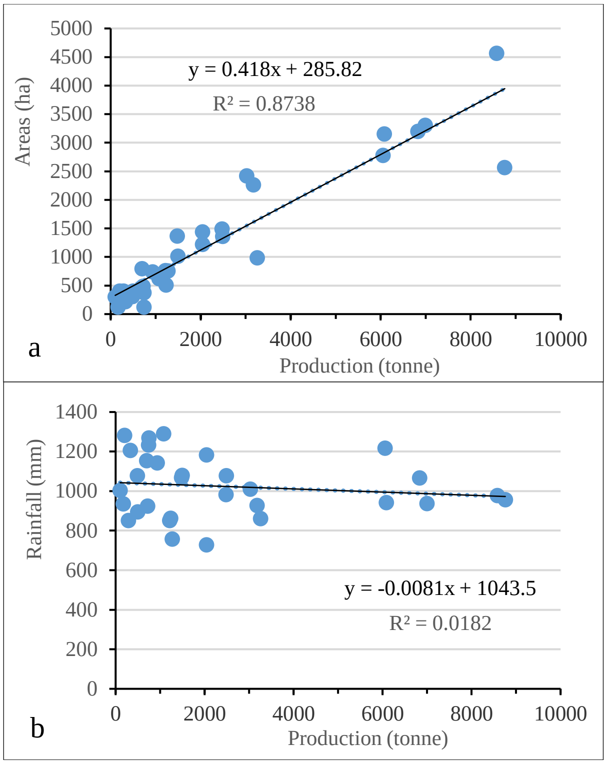

Figure 7: Correlation between rice production and area (a) and rainfall (b)
Source: National Meteorological Agency (Burkina Faso)

The rice production is therefore a function of the area sown. However, only the yield per hectare is a good indicator of production, because on a small area sown, production can be higher than on a large area. In other words, the area can decrease while production increases. Synchronic analysis of the production and area (Figure 6) indicates the peak of production in 2013 with 8,758 t of rice cultivated on 2,563 ha compared to 8,581 t cultivated on 4,566 ha in 2017. The area cultivated doubled for almost identical production. Under these conditions, the lowlands and the water reservoir (photo 1) are considered to be new capital on which to diversify production systems for the benefit of rural households

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Photo 1: Rice paddy downstream of the Boura Dam in Sissili Province
Source: SANOU Korotimi, July 2021

As for rainfall (Figure 7b), the proportion of uncorrelated variance ($100\text{-}r^2$) with rice production is very high (98 %) than for area (13 %). The correlation is almost zero. This implies that although rainfall is a determinant, rainfall alone is not a guarantee of good rice productivity. However, good rainfall creates optimal production conditions, provided that the technological packages and agricultural calendar are respected.

Between constraints production and socio-economic benefits

In Sissili province, rice production is essentially rainfed, as elsewhere in Burkina Faso. The lowlands are the preferred production sites, characterized by hydromorphic soils capable of ensuring prolonged waterlogging, which makes them suitable for growing rice, sorghum, and market gardening. Rice cultivation occupies about 56 % of the lowlands and irrigated areas planted by respondents, who explain their choice by the fact that rice needs sufficient water to keep the soil flooded until the seeds ripen. However, the exploitation of lowlands is not always easy, and the difficulties that arise are both natural and man-made.

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As soon as the season is definitively established in May, farmers (96 % of those surveyed) sow their crops. However, the technical itineraries recommended by agricultural technicians are not being followed. According to the farmers, plowing of the plots is mostly done with a daba (65 %), a plow (31 %), and a tractor (4 %). The plowing stage is generally associated with the establishment of nurseries when the soil is well waterlogged. After plowing, farmers proceed to level the plots and then transplant them. This last step, which should be carried out three to four weeks after the plot has been mudded, is skipped by many farmers. Indeed, about 57 % of farmers estimate that they observe two weeks for transplanting, compared to 15 % who go straight to planting after leveling. These practices will undoubtedly have an impact on yields.

The other constraint is the multifunctionality of wetlands, where herders and farmers live side by side. For sedentary and transhumant herders, the lowlands are their last resort in search of fodder resources for feeding and watering their herds. It is also a source of production for farmers both in the rainy season (rice, sorghum, millet, corn) and in the dry season (market gardening). Its use throughout the year generates conflicts between different categories of users. The damage caused by animals in both market gardens and rice fields was mentioned by 47 % of farmers. They estimate that the damage is considerable in terms of yield on the small portions of the plots that are farmed (0.12 ha to 0.50 ha). The fragmentation of cultivated land is linked to the depletion of natural resources and the diversity of actors (farmers, herders, fishermen, brick makers, etc.), as all have a right to the production resource.

While the popularization of rice production meets the demand for food satisfaction among urban dwellers, it also has an impact on the diet of farmers. Once considered a rich man's food or a holiday meal in rural areas, rice is increasingly present in the dietary habits of farmers. For 75 % of farmers, in addition to self-consumption, marketing rice improves their living conditions and enables them to meet household needs. Rice production is doubly beneficial for the population.

Discussion

As in the Sissili province, the succession of dry years has been noted by Kabore and *al*. (2018) at the Djibo station with adverse effects on agricultural and pastoral production. For Serpantie and *al*. (2019), a frequency of very dry decades hardens the soil and compromises plowing in the lowlands. The climatic constraints are accentuated by the rise in temperature with a positive steering coefficient of 0.024, which can harm production. Indeed, the United Nations Environment Program (2011) estimates that a temperature increase of 2°C could lead to a 15 to 25 % decrease in cereal production in Burkina Faso. Over the normal observation series (1988-2018), the seasonal evolution is almost identical over the three decades, with a wet season varying from five to six months. This constant beginning and end of rains, without significant variation, is also noted by Serpantie and *al*. (2019) on a decadal frequency (1922-2013) carried out in the Sudanian zone in Burkina Faso.

Yameogo and *al.* (2019), the increase in area is the result of the implementation of an agricultural policy, as was the case between 1992 and 1997 when the increase in the purchase price per kilogram of rice led to an expansion of rice fields from 25,000 ha to 53,600 ha. Population growth, urbanization, and changes in dietary habits have led to an increase in demand for agricultural products, resulting in an expansion of rice fields. Also, Serpantie and *al* (2019) consider that, in addition to the economic situation, the cost of production and the behavior of the market toward cotton production are indicators that justify the enthusiasm of rural populations for rice cultivation in the wetlands. To this end, the intensification of irrigated agriculture could be a boon to the development of hydroagricultural facilities (Faures and Sonou, 2000). Serpantie and Zombre (1994) consider that the rainfall regime associated with the variation in surface conditions is the main variants that affect rice production. These factors also provide suitable conditions for the proliferation of plants that are harmful to cereal production, particularly rice and sorghum. Thus, wetlands are generally colonized by highly invasive aquatic vegetation. The constraint of weediness requires a very early first weeding; the number of weedings varies according to the type of crop, up to three for sorghum (Serpantie and Zombre, 1994). To cope with production difficulties, the respondents opted for a series of strategies. These include early planting and adapting the technical itinerary. According to the latter, in the event of flooding, the most sensitive young rice stalks, notably the improved varieties (Manzanilla and *al*., 2011 in Serpantie and *al*., 2019), are high enough to cope. This strategy is also adopted by farmers in traditional lowlands in Danos by Palé and Da (2016) and in Niger, farmers adopt staggered sowing dates and irrigation (Tahirou and *al*., 2021). In addition, the abandonment of the actual itinerary of cultivation techniques by farmers, as popularized by the technicians who are responsible for monitoring the farms, is confirmed by Palé and *al*. (2016) at the level of the managed lowlands in Dano. In Benin, rice farmers believe that rice intensification systems (RIS) should be adapted to local production conditions to increase yields (Gbenou and *al*., 2016).

Formerly marginal lands, the depressed areas commonly called lowlands or floodplains are objects of covetousness (Sanou and *al*., 2015). Indeed, lowlands are strategic spaces for local and transhumant herders due to the availability of water, perennial shrubs, and fodder production for animals (Serpantie and *al*., 2019; Sanou and *al*., 2018; Lavigne Delville and Camphuis,

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

1998). The popularity of these multifunctional spaces is linked to the cash income and food security that have a socio-economic impact on rural farmers (Serpantie and *al*., 2019; Yameogo and *al*., 2019; Lavigne Delville and Camphuis, 1998). As for food availability, Serpantie and *al*. (2019), report that the frequency of rice consumption compared to other cereals varies from 7 % to 14 % per week with an estimated marketing rate of 45 % of production among farmers in southwestern Burkina Faso. In the rural town of Bilanga, Gnagna province, the Eastern region of Burkina Faso, Sanogo (2019) estimates the economic rent from lowland farming at 300,000 FCFA for 87 % of rice farmers and 12 % who are self-consuming.

Conclusion

This study allowed us to assess the correlation between rice production, area, and climatic parameters. The evolution of production seems to be explained by the extension of rice fields, which is a strategy for dealing with a possible decrease in rainfall. In the same way, land management techniques influence the yield of sown areas.

The early or late arrival of rains, the pockets of drought persistence, and the failure to respect the technological package are all elements that hinder the smooth running of rice-growing activities, with their impact on production. Notwithstanding these difficulties, the availability of food at the household level and the guarantee and strengthening of producers' monetary income underpin the rural population's enthusiasm for the rice sector.

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