IMPACT OF CLIMATE CHANGE ON CEREAL YIELD AND PRODUCTION IN THE SAHEL: CASE OF BURKINA FASO

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Abstract:

Climate change is one of the biggest challenges of the 21st century. It affects all countries in the world, especially Sahelian countries in Africa. This paper aimed at evaluating the impact of climate change on cereal yield in Burkina Faso. The ordinary least squares (OLS) was applied to time-series data from 1991 to 2016 collected on the World Bank website. The results have shown that temperature adversely affects yield and cereal production, while precipitation has positive effect. An increase in rainfall of 1 millimetre would increase cereal production by 385 tons in the long term and 252 tons in the short term. In the same, an increase in rainfall of 1 millimetre would increase agricultural yield by 9 kg per hectare in the long term. However, in the short term, an increase in temperatures of 1°C would result in a decrease in cereal production and agricultural yield of 134748 tons and 72 kg per hectare, respectively. However, in the long term, a rise in temperatures of 1°C would result in a decrease in cereal production and cereal yield of 154 634 tons and 1074 kg per hectare, respectively. Besides, the results indicate that the emission of carbon dioxide (CO_2) has no significant effect on yield and cereal production. Implementing effective adaptation strategies, such as access to improved seed, introduce smart agriculture in the system of cereal in Burkina Faso and increasing irrigation infrastructure could reduce the cereal production's vulnerability to climate shocks.

Keywords: Climate change, cereal production, cereal yield, Burkina Faso.

JEL Code: Q54, N57, Q19.

Résumé :
Le changement climatique est l’un des plus gros défis du XXIème siècle. Ce phénomène touche la plupart des pays africains, notamment les pays sahéliens. L’objectif de cet article est d’évaluer l’impact du changement climatique sur le rendement et la production céréalière au Burkina Faso. La technique des moindres carrés ordinaires (MCO) a été appliquée aux données secondaires collectées sur le site de la banque mondiale de 1991 à 2016. Les résultats montrent que la température affecte négativement le rendement et la production céréalière tandis que la précipitation les affecte positivement. Une augmentation des précipitations de 1 millimètre provoquerait une augmentation de la production céréalière de 385 tonnes à long terme et 252 tonnes à court terme. De même, une augmentation des précipitations de 1 millimètre provoquerait une augmentation du rendement agricole de 9 kg par hectare à long terme. Par contre, à court terme, une augmentation des températures de 1°C provoquerait une diminution de la production céréalière et du rendement agricole respectivement de 134748 tonnes et de 72 kg par hectare. Mais à long terme, une augmentation des températures de 1°C provoquerait une diminution de la production céréalière et du rendement agricole respectivement de 154 634 tonnes et de 1074 kg par hectare. Par ailleurs, les résultats indiquent que l’émission du dioxyde de carbone (CO_2) n’a aucun effet significatif sur le rendement et la production céréalière. La mise en œuvre de stratégies d’adaptation efficaces, la diversification de l’économie et l’augmentation des infrastructures d’irrigation pourraient réduire la vulnérabilité du pays aux chocs climatiques.

Mots clés : Changement climatique, production céréalière, rendement agricole, Burkina Faso.

Code JEL : Q54, N57, Q19.

Introduction

One of the biggest challenges of this century is climate change, which affects almost every country in the world with disastrous consequences for livelihoods (Erenstein and Ali, 2017, Xie and al, 2018). Mainly is due to human activities, particularly industrial activities that lead to a high rate of emission of greenhouse gases into the atmosphere (Shi and al, 2018). This causes global warming and frequents extremes climate such as drought and the flood.

Although Africa contributes only marginally to global pollution (10%), it is most affected by climate change (Sarker and al, 2014; IPCC, 2014). The Intergovernmental Panel on Climate Change forecasts a decline in agricultural productivity from 21 to 9 per cent in sub-Saharan Africa by 2080 (IPCC, 2007). Climate change effects are particularly severe in Sahelian countries. Roudier and al (2011) indicate that the Sudano-Sahelian countries (located in the North of West Africa) could experience a loss of agricultural yields higher (18%) compared to the countries located in South-West Africa (11%). Mendelsohn and al (2000) and Maddison (2007), argued that Burkina Faso and Niger could experience a loss in agricultural production of 19.9% and 30.5% respectively by 2050.

Also, the agricultural system that prevails in most African countries remains rain-fed, therefore highly depend on climatic conditions (Sultan and al., 2012). It explains the relatively high sensitivity of the agricultural sector to climate change (Sultan, 2017). The vulnerability of this sector is linked to the increase of temperature and the decrease in rainfall. Between 1991 and 2016, the temperature increased from 23.16°C in January 2008 to 33.83°C in April 2016 and rainfall dropped from 290.26 mm in August 1994 to 144.11 mm in September 2016 in Burkina Faso (World Development Indicator (WDI), 2019).

Empirical studies are almost agreed on the sensitivity of agriculture to climate change. Mohamed and al. (2002) analysed climate variability on millet production in Niger and found that this issue can cause a decline in millet production of 13% by 2025. Wossen and al (2018) showed that climate and price variability negatively affect household income and food security in Ethiopia and Ghana. Similarly, in Malawi, the work of Warnatzsch and Reay (2019) indicated that changes in temperature and precipitation are not favorable for agricultural activities.

In a recent study, Houngbedji and Diaw (2018) showed that the concentration of CO_2 negatively influences agricultural production in Benin. In Burkina Faso, Ouedraogo (2012) showed that climate change has a negative impact on the agricultural sector. The author concludes that the impact of temperature on-farm income is -19.9 $ USD per hectare, while that of rainfall is + 2.7 $ USD per hectare. Besides, the author reveals that when rainfall increases by 1%, farm income increases by 14.7% while an increase in temperature of 1% leads to a decrease in agricultural income of 3.6%.

Agricultural sector sensitivity to climate change has been widely discussed in West Africa, but there are still few studies on the vulnerability of agriculture in Burkina Faso. This paper assessed the impact of climate change on cereal yield and cereal production in Burkina Faso. The ordinary least squares (OLS) was applied to time-series data from 1991 to 2016 collected on the World Bank website. The results show that climatic variables such as temperature and precipitation significantly affect cereal yield and cereal production in Burkina Faso. Precipitation positively effects while temperature negatively effects. Results also indicate that the emission of CO_2 has no significant effect on cereal yield and cereal production.

The next step of the paper presents an empirical literature review, followed by research method. Results and discussion come after, and the conclusion ends the paper.

1. Empirical review

Climate change has been a frequent subject in several fields of research. Economics researchers have analysed the impact of climate change on agricultural incomes through production or agricultural output.

Concerning the impact on farm incomes, most authors conclude that climate change tends to reduce agricultural incomes, particularly in Africa, where dependence on agriculture is relatively high. Wossen and al (2018) conducted a study in Ethiopia and Ghana and argue that climate and price variability would negatively affect income and food security. They propose several adaptation strategies such as improving the supply of credit to production, access to improved seeds and increasing irrigation infrastructure. Similarly, Ouédraogo (2012) in Burkina Faso indicated that climate change is having a negative impact on the agricultural sector. According to him, the country's agricultural sector is susceptible to rainfall variations. The impact of temperature on-farm income is -19.9 $ USD per hectare, while rainfall is about + 2.7 $ USD per hectare. In addition, a 1% increase in rainfall leads to an increase in agricultural income of 14.7% while a 1% rise in temperatures leads to a decrease in agricultural income of 3.6%. The author finally reports that an increase in temperature of 5 ° C could cause to farmers losing 93% of their income, while a decrease in rainfall of 14%, farmers risk losing all their income.

Most studies established a relatively negative link between climate change and agriculture at the global level, in Asia as well as in Africa. These studies confirmed the vulnerability of the agricultural sector to climate change. Ding and al (2017) used data from 109 countries to assess the impact of climate change on fisheries and food security. They indicated that developing countries in Africa, in Asia, in Oceania and Latin America are the most vulnerable to climate change. Raymundo and al (2018) also analysed the impact of climate change on global potato production. Their results indicate that a high concentration of CO_2 in the atmosphere and an increase in temperature would cause a downward trend in tuber production. Also, forecasts of global tuber production are worrying, ranging from a 6% drop by 2055 to a 26% decrease by 2085.

Intergovernmental Panel on Climate Change points out that the impact of climate change on agriculture varies from place to place. In temperate regions, moderate global warming (temperature increase of 1 to 3°C) would positively affect agricultural yield while in tropical regions, it would negatively affect cereal production (IPCC, 2007). However, warming above 3°C would have negative effects on agricultural production. Sarker and al (2014) show that the average maximum temperature has a negative impact on rice production while the average minimum temperature is favorable for rice production Bangladesh.

In Asia, Shi and al (2018) showed that food production and consumption lead to significant greenhouse gas emissions that affect the environment, which in turn affects agricultural yields. Similarly, Ruszkiewicz and al (2019) reported that climate change disturbs the quantity and quality of water, which affects food production. Xie and al (2018) found that climate change would cause a drop in wheat yield of 9.4% by 2050 in China. In the same way, Lu and al (2019) confirmed the persistent effects of climate change in China. Using a Cobb-Douglas production function, the authors concluded that climate change is having an increasingly severe impact on China's water resources and grain production.

In Africa case, Knox and al (2012) showed that by 2050, agricultural yields would fall by 8% on average due to climate change. According to these authors, cereals like wheat, maize, sorghum and millet will decline by 17%, 5%, 15% and 10% respectively. Schlenker and Lobell (2010) analysed the impacts of climate change on agriculture and found that climate change has contributed to lower production of maize, sorghum, groundnut, millet and cassava, respectively. 22%, 17%, 18%, 17% and 8% in SSA. Warnatzsch and Reay (2019) showed that changes in temperature and precipitation are not favorable for agricultural activities in Malawi.

Most studies in West Africa indicate that climate change does affect countries in the same way. Indeed, the Sahelian countries are more vulnerable to the phenomenon. Roudier and al (2011) indicated that the Sudano-Sahelian countries (located in the North of West Africa) could experience a loss of agricultural yield (18%) higher compared to the countries located in South-West Africa (11%). Moreover, according to the work of Mendelsohn and al (2000) & Maddison (2007), Burkina Faso and Niger are likely to experience a loss of agricultural production of 19.9% and 30.5% respectively on the horizon. 2050. Similarly, by studying the impact of climate variability on millet production in three major producing regions of Niger, Mohamed and al. (2002) showed that climate change would lead to a 13% decline in millet production by 2025.

In conclusion, this empirical work highlights the vulnerability of agriculture to climate change, particularly in Africa. The impacts of climate change on cereal production would be particularly pronounced in Sahelian countries (Zhu and al., 2018).

2. Methodology

2.1. Framework of study

Burkina Faso is a landlocked country in West Africa, bordered on the North by Mali, on the South by Ghana and Togo, on the East by Niger, on the South-East by Benin, and the South. West by Ivory Coast. Covering an area of 274,200 km2, this country has a total inhabitant of 19,751,535 in 2018 (WDI, 2019). Three climatic zones characterise this country (see Figure 1) namely (i) the Sudanian zone to the South, (ii) the Sudano-Sahelian zone going from East to West and (iii) the Sahelian zone to the North. The Sudano-Sahelian zone is much larger than the other two climatic zones.

Figure 1: Map of climatic zones in Burkina Faso

Source: Kaboré and al (2017)

3. Data

Our data was the time series from 1991 to 2016 collected on the World Bank website.

3.1. Methodological approach

Following Lu and al., (2019), they used a Cobb-Douglas production function to show that climate change is having an increasing impact on forest resources, water and grain production. They also used a production function to assess the impact of climate change (temperature, precipitation and carbon dioxide (CO2) emissions) on cereal yield and cereal production in Burkina Faso. The mathematical form of this function is as follows:

$$Y = \alpha_0 + \alpha_1 F + \alpha_2 Z + \varepsilon \quad \textbf{(1)}$$

Where **Y** captures cereal production or agricultural yield, **F** captures the linear relationship between production and climate, **Z** represents control variables such as rainfall squared, temperature squared and factors of production, are parameters to estimate then u represents the error term of the model. The quadratic terms of the model capture the non-linear relationship between production and climate.

The empirical models that will be tested in this research are as follows:

Model 1: Agricultural Performance Model

$$CY_t = \beta_0 + \beta_1 RF_t + \beta_2 TEM_t + \beta_3 CO2_t + \beta_4 (RF_t)^2 + \beta_5 (TEM_t)^2 + \beta_6 RPG_t + \beta_7 GRCL_t + \varepsilon_t \quad \textbf{(2)}$$

Model 2: Cereal Production Model

$$PROD_t = \beta_0 + \beta_1 RF_t + \beta_2 TEM_t + \beta_3 CO2_t + \beta_4 (RF_t)^2 + \beta_5 (TEM_t)^2 + \beta_6 RPG_t + \beta_7 GRCL_t + \varepsilon_t \quad \textbf{(3)}$$

Where **CY** (Cereal Yield): is the cereal yield expressed in kilograms (kg) per hectare (ha). It is calculated based on dry grain harvests only like rice, maize, sorghum and millet. This variable represents the dependent variable of the first model.

PROD is the cereal production of Burkina Faso expressed in metric tons. This variable represents the second model dependent variable and refers to dry grain crops only.

RF is the average annual rainfall expressed in millimetre (mm). This variable measures the amount of precipitation recorded annually in Burkina Faso.

TEM is the average annual temperature expressed in degrees Celsius. This variable represents the average of the minimum and maximum temperatures recorded annually in Burkina Faso.

CO2 is the average amount of carbon dioxide emitted annually in Burkina Faso. It is expressed in kiloton (kt). It takes into account carbon dioxide emissions from the use of fossil fuels or cement manufacturing. It also includes carbon dioxide produced during the consumption of solid, liquid or gaseous fuels.

RF2 is the square of the rainfall. This variable makes it possible to test the non-linear relationship that could exist between production and climate.

TEM2 is the square of the temperature. This variable also makes it possible to test the non-linear relationship that could exist between production and climate.

RPG (*rural population growth*): is the growth rate of the rural population expressed as a percentage. The rural population represents people living in rural areas. It is calculated by subtracting the total population from the urban population.

GRCL (*growth rate of cereal land*): is the area of land devoted to cereal production. It is expressed in hectare and refers to dry grain crops only such as rice, maize, sorghum and millet.

The estimation strategy consists, firstly, in the application of standard unit root and cointegration tests, and then in estimating the empirical models using ordinary least squares (OLS).

4. Results and discussions

4.1. Descriptive analysis

Table 1: Descriptive statistics

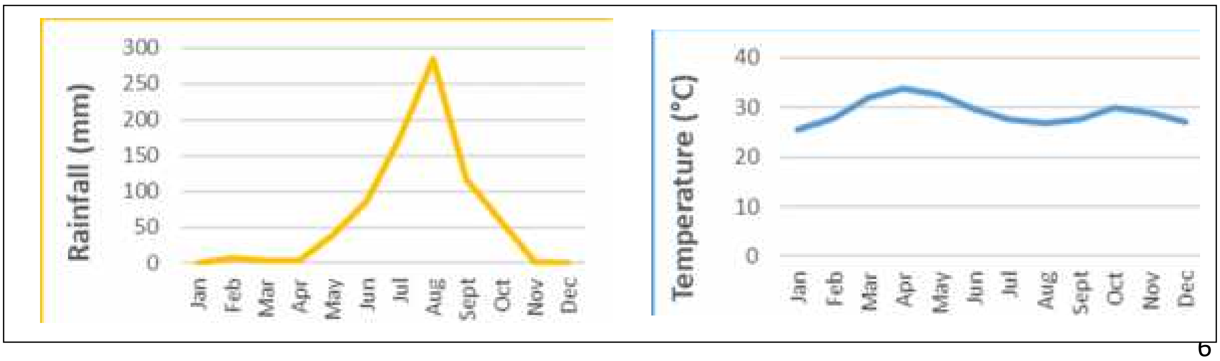
Variables	Years	Number of Observations	Min	Max	Mean
RF	1991-2016	26	676.83	941.86	798.97
TEM	1991-2016	26	28	29.13	28.70
PROD	1991-2016	26	2013552	4898544	3325844
CY	1991-2016	26	704.5	1225.8	988.77
CO2	1991-2012	22	11859.68	50062.48	34280.9
RPG	1991-2016	26	1.96	2.44	2.18
GRCL	1991-2016	26	2661349	4291496	3314568

Source: Authors, from WDI data (2019)

Table 1 presents the descriptive statistics of the variables used in the two models to estimate the impact of climate change on cereal production in Burkina Faso The data are annual and cover the period from 1991 to 2016 except the data on the emission of carbon dioxide (CO_2), which lasts in 2012. In Burkina Faso, the average CO_2 emissions are about 34 280.9 kilotons per year, and the cereal yield produced remained low 989 kilograms (kg) per hectare (ha). Cereal production varies between 2 and 4 million of tones with an annual average of 3,325,844 tones. The rural population is 2.18% of the total population. The cultivated area of cereal crops is 3,314,568 hectares. In this country, on average, rainfall and temperature are respectively 798.97 millimetre (mm) and 28.69 degrees Celsius (°C) with a respective maximum value of 941.86 mm and 29.13 °C.

Referring to Figure 1, the country has two (02) seasons (rainy season and dry season). The rainy season lasts about 4 months, from May-June to the end of September or beginning of October and the dry season lasts about 8 months, between October and the end of April, or even May in the North region (totally desert region). Overall, the country is characterized by a relatively high atmospheric temperature throughout the year. It is often warmer in the North than in the South.

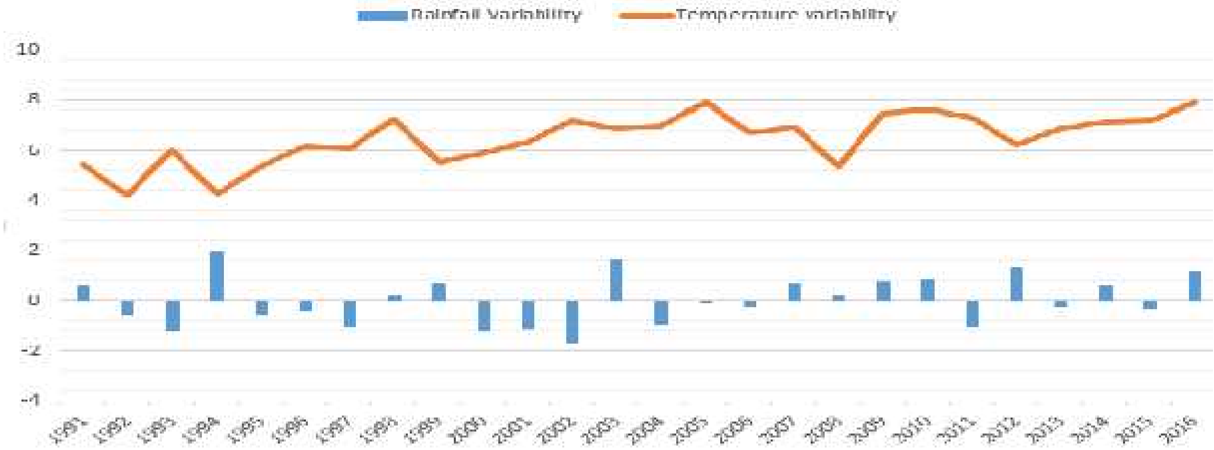
Figure 1: Evolution of rainfall and temperature in Burkina Faso in 2015



Source: WDI, 2019

Figure 2 reports the evolution of rainfall and temperature. Rainfall highly varies over time. When we take a look at the figure reporting the temperature, we can acknowledge that there is an increase in temperature over the period.

Figure 2: Evolution of rainfall variability and temperature in Burkina Faso



Source: WDI, 2019

4.2. Results of the unit root test

Table 2 contains the test of stationarity. To avoid fallacious regressions, it is necessary to check the property of stationarity or not of the variables. To do this, several unit root tests can be used, such as the Phillips-Perron test (PP, 1988), the Augmented Dickey-Fuller test (ADF, 1981) and the Kwiatkowski, Philips, Schmidt and Shin test (KPSS), 1992). In this study, we use the Augmented Dickey-Fuller (ADF) to test stationarity of the variables. Overall all variables are stationary in level except the emission of carbon dioxide (CO2) and the growth of the rural population, which are stationary in first difference.

Table 2: Increased Dickey-Fuller Unit Root Test Results

Variables	Level		First difference		Decision
	ADF	PROB	ADF	PROB	
PROD	-5.75 [3]	0.0004			I(0)
RF	-6.98 [3]	0.0000			I(0)
TEM	-4.72 [3]	0.0047			I(0)
CO2	0.24 [1]	0.746	-5.90 [3]	0.0006	I(1)
RPG	-0.68 [1]	0.411	-2.76 [2]	0.0779	I(1)
GRCL	-4.41 [3]	0.0093			I(0)

Note: ADF: Augmented Dickey-Fuller, [1]: Model without constant or deterministic trend; [2]: Constant model with no deterministic trend; [3]: Model with the constant and deterministic trend.

Source: Authors, from WDI data (2019)

4.3. Johansen cointegration test results

Since not all our variables are integrated in the same order, we use the Johansen cointegration test, which has the merit of applying to all cases. Indeed, Johansen

(1988) proposes maximum likelihood estimators to test the cointegration of series. It performs a cointegration rank test. As shown in Table 3, the RF variable is cointegrated to the PROD variable at 5% threshold. Then, we can deduce that climatic variables are cointegrated at cereal production at the 5% threshold.

Table 3: Johansen cointegration test

Variables	**Hypothesis**	**Eigen-value**	**Statistic**	**Critical value**	**Prob**
	None	0.53	18.56**	15.49	0.016
PROD RF	At most 1	0.02	0.40	3.84	0.527
	None	0.31	9.16	15.49	0.35
PROD TEM	At most 1	0.02	0.38	3.84	0.53
	None	0.26	6.57	15.49	0.63
PROD CO2	At most 1	0.03	0.53	3.84	0.47
	None	0.24	6.89	15.49	0.59
PROD RPG	At most 1	0.02	0.46	3.84	0.50
PROD	None	0.40	12.66	15.49	0.13
GRCL	At most 1	0.01	0.31	3.84	0.57

* indicates significance at the 10% threshold, ** significance at the 5% threshold and *** significance at the 1% level

Source: Authors, from WDI data (2019)

4.4. Empirical results

The empirical results present both long-term and short-term results.

4.4.1. Long-term dynamics

Table 4 presents the long-term dynamics of the impact of climate change on both cereal yield and cereal production in Burkina Faso. Columns (1) and (2) present the results for cereal yield (model 1) and columns (3) and (4) present the results for cereal production (model 2). Columns (2) and (4) contain the results of the quadratic variables introduced in the models in order to test the non-linearity of the relationship between climate and production. The Fisher test analysis indicates that the model is globally significant at 5% level. The R squared is about 0.33 in the first two columns and 0.84 in the last two columns. The grain production model shows a better quality of fit with the agricultural yield model. The quadratic variables are not significant, and one can thus deduce that in the long term, the relation between the climate and the production is linear in Burkina Faso.

Climate variables (precipitation and temperature) are significant at 10% level. Precipitation positively affects production and yield with coefficients of 384.70 and 9.17, respectively. Thus, an increase (or decrease) in rainfall of 1 millimetre would result in an increase (or decrease) in cereal production and cereal yield of 385 tons and 9 kg per hectare, respectively. Temperatures negatively affect production and yield with coefficients of -154,634.2 and -1073.74 respectively. It can, be concluded that an increase (or decrease) in temperatures of 1°C would result in a decrease (or increase) in cereal production and agricultural yield of 154 634 tons and 1074 kg per hectare, respectively.

Besides, the emission of carbon dioxide (CO2) has a negative sign but not significant. On the other hand, the area planted affects positively and significantly the cereal production. Indeed, since most African households practice extensive agriculture, the more the area planted increases, the more production increases.

Table 4: Long-term dynamics

	Model 1 Cereal Yield (CY)		Model 2 Cereal production (PROD)	
	(1)	(2)	(3)	(4)
Rainfall (RF)	0.108	9.17*	384.70*	27316.58
Temperature(TEM)	64.88	-1073.74*	-154634.2*	8854889
CO2	0.00003	-0.0004	-0.4227	-1.64
GRCL	0.00013	0.0001	1.437***	1.46***
RPG	-132.12	-192.38	-389242	-553166.8
RF^2		-0.005		-16.70
TEM^2		-18.08		-153452.7
Cons	-1111.68	-18682.82	-5380150	-1.39E+08
R^2 ajusté	0.33	0.32	0.84	0.83
Obs	22	22	22	22

* indicates significance at the 10% threshold, ** significance at the 5% threshold and *** significance at the 1% level

Source: Authors, from WDI data (2019)

4.4.2. Short-term dynamics

Table 5 below presents the short-term dynamics of the impact of climate change on the agricultural sector in Burkina Faso. Indeed, the coefficients associated with the standard error of the yield and output models are significantly negative and less than unity in absolute value. This justifies the validity of an error correction model.

In the short term, the relationship between climate change and production is linear in Burkina Faso because the quadratic variables are not significant. However, temperatures and precipitation are significant at the 10% threshold in the production model (model 2), but only the temperatures are significant in the model for yield (model 1). In the short term, rainfall positively affects production with a coefficient of 251.70. It can, therefore, be concluded that an increase (or a decrease) in rainfall of 1 millimetre would increase (or decrease) cereal production by 252 tons. Temperatures negatively affect production and yield with coefficients of -134748.3 and -72.39 respectively. Thus, an increase (or decrease) in temperatures of 1°C would result in a decrease (or increase) in cereal production and agricultural yield of 134748 tons and 72 kg per hectare, respectively.

Also, the emission of carbon dioxide (CO2) and the growth of the rural population do not have any significant effect on either production or yield. However, the area planted affects positively and significantly the cereal production in Burkina Faso.

Table 5: Short-term dynamics

	Model 1 Cereal Yield D(CY)		Model 2 Cereal production D(PROD)	
	(1)	(2)	(3)	(4)
D(RF)	0.2016	9.17	251.70*	29454.14
D(TEM)	-72.39*	1073.74	-134748.3*	8777553
D(CO2)	-0.0029	-0.0004	-9.0231	-1.24
D(GRCL)	7.93E-05	0.0001	1.3086***	1.47***
D(RPG)	143.44	-192.38	216850	-559677.6
D(RF^2)		-0.005		-18.05
D(TEM^2)		-18.08		-152298.8
Erreur (-1)	-0.1115***		-0.083***	
Cons	7.69	-18682.82	20751.97	-1.39E+08
R^2 ajusté	0.37	0.32	0.75	0.81
Obs	21	21	21	21

* indicates significance at the 10% threshold, ** significance at the 5% threshold and *** significance at the 1% level

Source: Authors, from WDI data (2019)

5. Discussion of results

Burkina Faso's cereal cultivation is highly sensitive to climate change. Rainfall positively affects agriculture. An increase in rainfall of 1 millimetre would increase cereal production by 385 tons in the long term and 252 tons in the short term. Similarly, an increase in rainfall of 1 millimetre would increase agricultural yield by 9 kg per hectare in the long term. Our results are contrary to those of Xie and al (2018) who indicated that climate change strongly affects agricultural production. Similarly, our results are contrary to those of Lu and al (2019) who used a Cobb-Douglas production function to show that climate change is having an increasingly severe impact on water resources and cereal production in China. In addition, our results show that rainfall does not significantly affect crop yield in the short term. These results confirm those of Houngbedji and Diaw (2018) who indicated that rainfall has no significant effect on cereal production in Benin.

Our results indicate that temperature adversely affects yield and cereal production in both the long term and the short term. In the short term, a rise in temperatures of 1°C would result in a decrease in cereal production and agricultural yield of 134748 tons and 72 kg per hectare, respectively. However, in the long term, a rise in temperatures of 1°C would result in a decrease in cereal production and agricultural yield of 154 634 tons and 1074 kg per hectare, respectively. Our results are consistent with those of Knox et al. (2012) who indicate that by 2050, the increase in temperatures would lead to a decline in agricultural yields of 8% in both Africa and South Asia. In Africa, decreases would be in the order of 17%, 5%, 15% and 10% respectively for wheat, maize, sorghum and millet. Similarly, our results confirm those of Nonvidé and Porgo (2014) who indicated that cereal yield is sensitive to temperature in Benin. However, our results are contrary to those of Sarker and al (2014) who indicated that the minimum average temperature is favorable for rice production in Bangladesh.

Carbon dioxide (CO_2) emissions have a negative but not significant in both situation the long term and the short term. These results go against Houngbedji and Diaw (2018) result, they argued that the concentration of carbon dioxide (CO_2) significantly affects agricultural production in Benin. However, our results are in line with Raymundo and al (2018) results. They concluded that a high concentration of carbon dioxide (CO_2) in the atmosphere and an increase in temperature would cause a drop in world production of tubers of 26 %.

Conclusion

This paper assessed the impact of climate change on cereal yield and cereal production in Burkina Faso. Sahelian countries are the most vulnerable countries to the effects of climate change in Africa. The ordinary least squares (OLS) was applied to time-series data from 1991 to 2016 collected on the World Bank website. The results show that climatic variables such as temperature and precipitation significantly affect cereal yield and cereal production in Burkina Faso. Precipitation positively effects while temperature negatively effects. The long-term effects are higher than those in the short term. An increase in rainfall of 1 millimetre would increase cereal production by 385 tons in the long term and 252 tons in the short term. However, in the long term, a rise in temperatures of 1°C would result in a decrease in cereal production and cereal yield of 154 634 tons and 1074 kg per hectare, respectively. Results also indicate that the emission of CO_2 has no significant effect on cereal yield and cereal production. Implementing effective adaptation strategies, such as access to improved seed, introduce smart agriculture in the system of cereal in Burkina Faso and increasing irrigation infrastructure could reduce the cereal production's vulnerability to climate shocks.

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