

Climate Variability And Peasant Agriculture In Kélo In The South Of Chad

Abdoulay Mfewou

Lecturer, Researcher, Department of Geography
and Rural Development, University of Dschang, Cameroon

Julius Tata

Lecturer, Researcher, Department of Geography
and Rural Development, University of Dschang, Cameroon

Paul Nadji

Geographer, Department of Geography and
Rural Development, University of Dschang, Cameroon

ABSTRACT

With its Sahelian climate, Chad presents climatic parameters which have a very negative impact on its agricultural productivity. Faced with this natural problem for peasant society, political decision-makers do little to support local adaptation mechanisms. The study in Kélo, southern Chad, (606.9 mm; 28.9 ° C) was carried out for five months. The survey was conducted with 140 heads of households randomly chosen from this area to collect information relating to the damage caused by climatic vagaries on the yields of cultivated plants and the analysis of meteorological data collected at the Kélo station by I 'Chad Institute of Agronomic Research for Development (ITRAD) on climate variability which shows the irregularities of the rains at their beginnings and / or at their ends, the shortening of the rainy season and, a slight rise in temperature. These rainfall irregularities, the main crops are experiencing yield reductions of the order of 70% of the average, approximately: 20-25 bags of paddy per hectare against 7-12 bags of paddy for rice, 4-5 bags / ha against 2-3 bags / ha for sorghum and pearl millet, 10-13 bags / ha against 6-9 bags / ha for peanuts, 600-900 kg / ha against 250-600 kg for cotton, etc. . In 2018, rainfall over time shows linear correlations established between cereal and cotton yields on the one hand, and those of annual rainfall on the other. The result also shows that there are no explicit linear relationships between these variables. This shows that, mere knowledge of the rainfall regime is not enough to explain the decline in agricultural production; because poor agricultural production can result from both poor and surplus water conditions and / or poor distribution of rains. It is recorded that food production per capita also decreases; this decline occupies a very important place in all policies of local development projects but weakly applied by rural decision-makers. Consequently, there is recurrent food

insecurity, putting the farmer in a dependency on assistantship from outside the region.

Keywords: Peasant agriculture, Socio-economic impact, Kélo Sud-du Tchad, Climate variability.

INTRODUCTION

The climate, agriculture and livelihoods of peasants in Kélo in southern Chad include an irregularity in the availability of basic foods, difficult stability of supply and poor access to supply. Chad, a central African country, has three climatic zones, the northern half of which is desert with insignificant annual precipitation (25 mm at Faya-Largeau), the central part of the Sahel receives more rain (250 to 500 mm per year) as is the tropical south with a rainy season. Thus, Kelo has a desert climate (BWh) according to the classification of Köppen-Geiger (2020). The average annual temperature is 28.9 °C and the precipitation averages 606.9 mm. The driest month is February. There is 4.1 mm of precipitation in February. The most precipitation falls in August, averaging 142.1 mm. The precipitation varies 138 mm between the driest month and the wettest month. The amplitude of the temperatures throughout the year is 7.1 °C. Kélo has a demography of 42,533 inhabitants in Kélo, this population (80%) lives from agriculture but does not escape the hazards induced by climatic variability and their socio-economic, environmental and more noticeable effects especially on income of households (Rabourdin, 2005, Smit, Skinner, 2002).

The natural phenomenon concerns the variability in the rainfall frequency, the cessation of rain during the wet seasons, as the severity of the dry seasons. These pluviometric irregularities have as a corollary the variability of the dates of starting of the agricultural campaigns, end and duration of the rainy seasons, associated with a greater occurrence of the excesses and the water deficits. The present study assesses the extent of rainfall irregularities and these impacts on peasant agriculture in Kélo in southern Chad. In other words, it aims to determine the impact of climate variations on the length of the growing seasons and on agricultural production.

Geographical Characteristic Of Kélo

In the study area, Kélo includes 2 cantons (Bagaye and Bayaka) and a municipality of 3 districts. It is located in the Province of Tandjilé, in the southwest of Chad. Between latitude 9 ° 19 'and 9 ° 40'N and longitude 15 ° 48' and 16 ° 10'E, this locality is an intermittent flood plain very sensitive to climatic risks. It is part of the climate zone known as the "Sudanian zone" (Atlas Tchad, 2013).

Generally speaking, all the subequatorial regions whose isohyets are between 800mm-2000mm / year are called the Sudanian zone. Thus defined, the Sudanian zone of Chad is between the 7th and 11th degree of the North attitude. It covers an area of 130,000 km² and is limited to the West by Cameroon, to the South by CAR, to the East by Salamat and to the North by Chari Baguirmi and Guéra. According to the new administrative division, it includes the provinces of Moyen Chari, Mandoul, Logone Oriental, Logone Occidental, Mayo-kebbi and Tandjilé, study area (INSEED, 2009). In terms of climate, Kélo is located in the tropical zone with two seasons: a dry season and a wet season of equal duration (6 months). The average rainfall over a 30-year period is 986mm. This rainfall allowed the development of a shrubby savanna dotted with trees sheltering in the past a rather rich fauna.

Initially inhabited by a population of hunters, Kélo becomes, following climatic variability and socio-economic changes, an area with an agro-pastoral vocation. However, in the 2000s, climatic variability made it increasingly difficult for the activities of this population, which found it difficult to adapt to it. It is often the victim of climatic hazards such as drought, its sandy beige soil and especially floods, the main cause of the destruction of culture and chronic food insecurity (Cabot J., 1965)

Ecology Of Cultivated Plants

Analysis of the ecology of plants cultivated at Kélo shows that this environment is very favorable for the development of these crops except rice (1000-1500 mm), yam (1000-1500 mm) and taro (1500- 2000 mm) which require a lot of water. This medium, which records approximately 950 mm of water per year with a thermal minimum of 20 ° C and a thermal maximum of 34 ° C, is not well suited to these plants (Map 1 and 2). This is why farmers often choose the flood plains for rice and taro. While the yam is not cultivated much in Kélo because of its water requirement. However, the climatic variability which has been reflected in recent years by poor distribution of rains and by a slight rise in extreme temperatures has a negative impact on the yield of these crops.

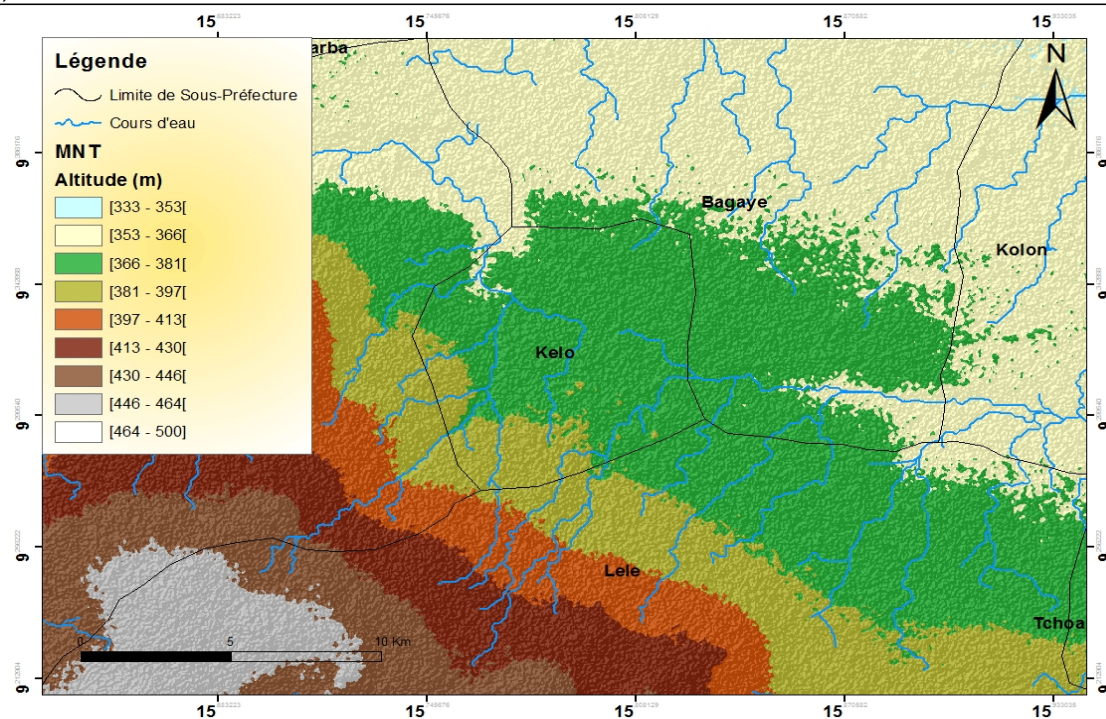
RESEARCH METHODOLOGY

The methodological approach used is based largely on the analysis of climate data from ITRAD (2020) and agricultural production data in the study area. Random data collection was carried out by survey, interviews and observations in the field in rural areas. The climate data analyzed on precipitation and temperatures are periods from 1982 to 2018 from ITRAD (2020).

The determination of the thermometric trends over the period (1982-2018) was made material graphic indicating the climatic variability over time thanks to the equation of the trend line is of the form $y = at + b$ where y represents the temperatures, and t time; a and b are constants. And our field observations are focused on Gaussen theory ($P = 2T$). The rainy season from an agricultural point of view is the period during which cultivated plants (often annual) can adequately meet their need for water (for the benefit of rain alone). It is fully defined if we know its beginning and its end. The start of the agricultural rainy season is very important for planting planning.

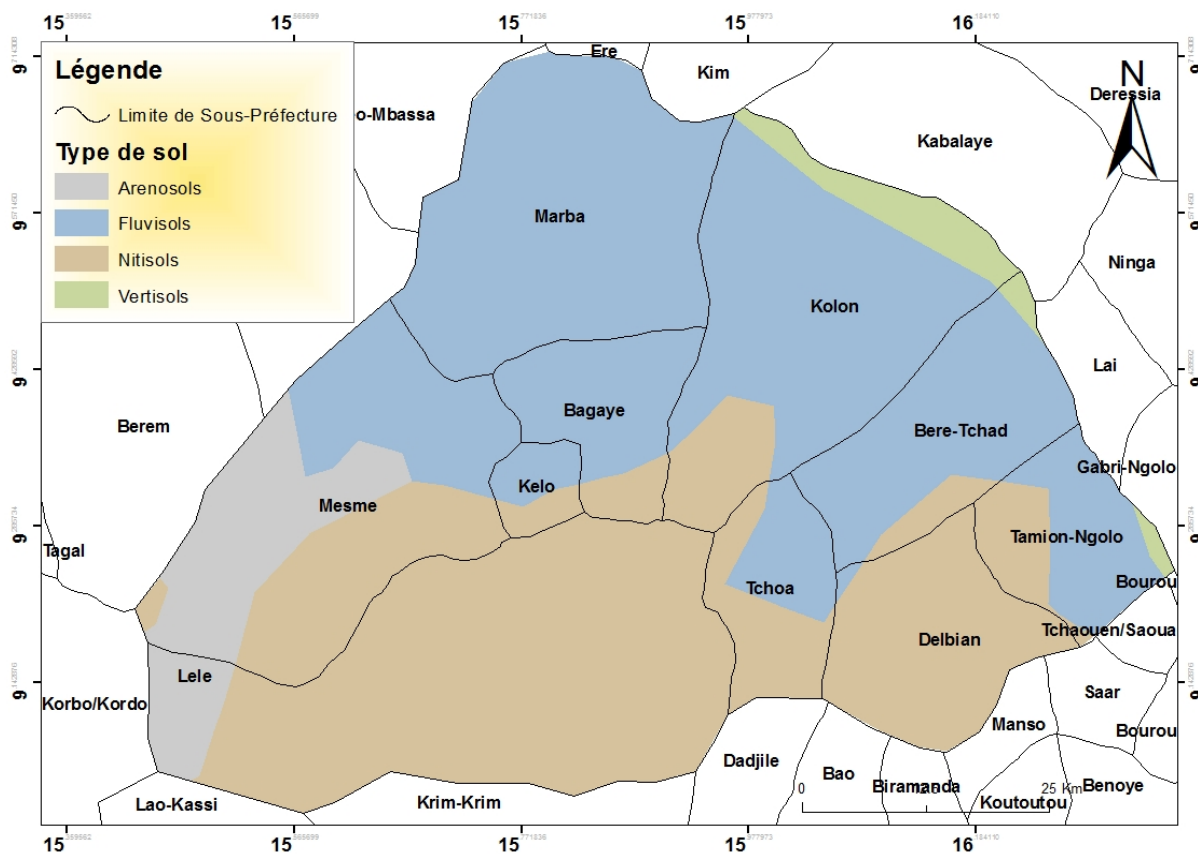
To analyze the level of coherence between perceptions and theoretical data, we thus calculated the characteristics of the season (start date, end date, duration), the monthly and annual cumulative for each year concerning the precipitation for the periods from 1982 to 2018. The average of these characteristics was calculated for this period and compared with the Student test (bilateral test) at 5% significance. These different climatic data were processed on annual and monthly scales in order to determine their impact on agricultural production in the study area: it is on the analysis of temperature variations according to the years, the interannual variations of the rains, irregularities in the rains at the start of the crop year.

Raw agricultural production data for cereals from the statistical directories of the former National Office for Rural Development (ONDR), now ANADR (National Agency for Rural Development), were used. These essentially cover the period from 2018 to 2002. Agricultural yields (quantity produced per hectare) therefore derive from the total production reported per hectare. We carried out a comparative study of yields for 2 consecutive years (1998 and 2018) to allow us to measure the impacts of climate variations on the yields of cultivated plants.



Map 1: relief and hydrology at Kélo

Source : SRTM 30 m



Map 2: Types of kelo soil

RESULTS AND DISCUSSIONS

In Kélo, activities are dominated by agriculture and animal husbandry, which depend on rains which become more and more irregular over the years. It is recorded that climate variability contributes to the impoverishment of peasants in the Sahelo-Sudanian zone of Chad by limiting or disrupting their activities (Figure 1).

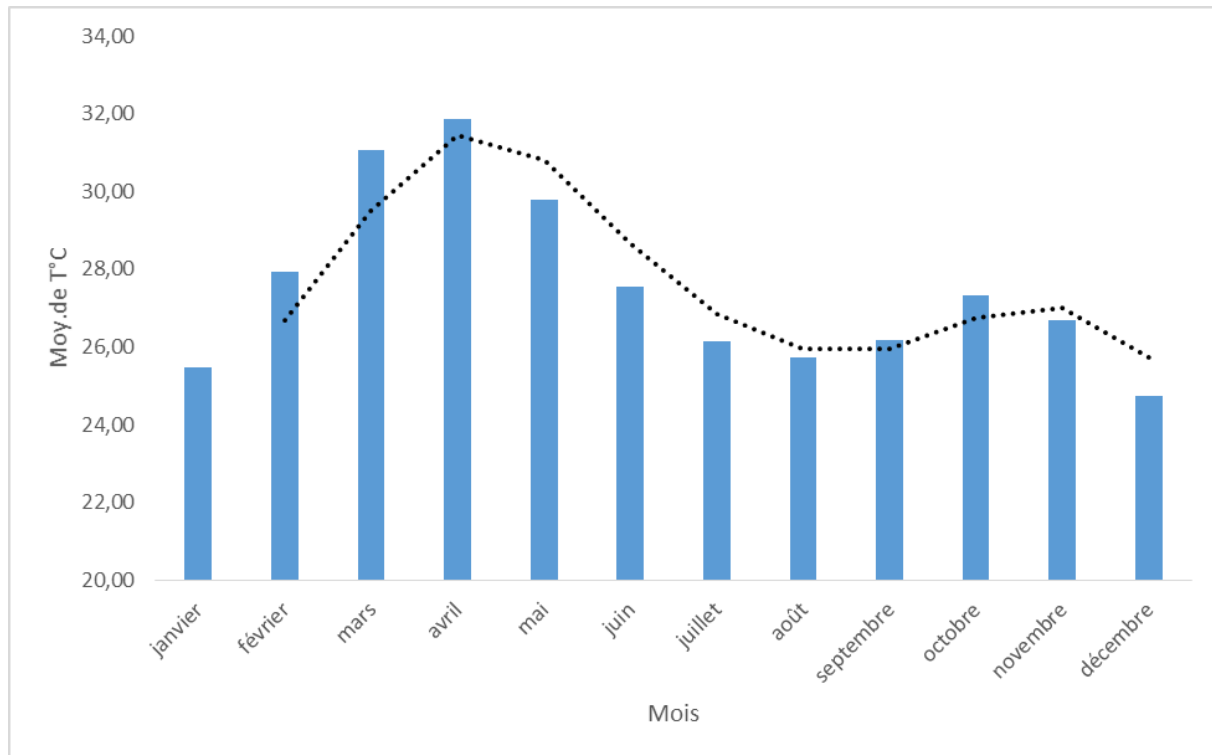


Figure 1: Monthly averages of temperatures from 1988 to 2018

This figure shows the variation of rains and temperatures during the year. The hottest first season starts from March to May, 3 months with an average high of 31.85 ° C in April and an absolute maximum which sometimes reaches 45 ° C in the shade. This hot season, which coincides with the start of the rainy season, has a very negative impact on sowing activities. This very high heat at the beginning of the rainy season often leads to the decay of germinating seeds or causes the drying of young cultivated plants (...). In the event of prolonged interruption of the rains, the heat favors the proliferation of pests such as striga, caterpillars, herbivorous insects and the development of certain adventitious plants which are very resistant to heat.

Temperature Variation By Year

Figure 2 explains the variation in temperatures over the years. The observation of this figure shows that the temperatures at Kélo are not stable. There is an alternation between hot years and cold years.

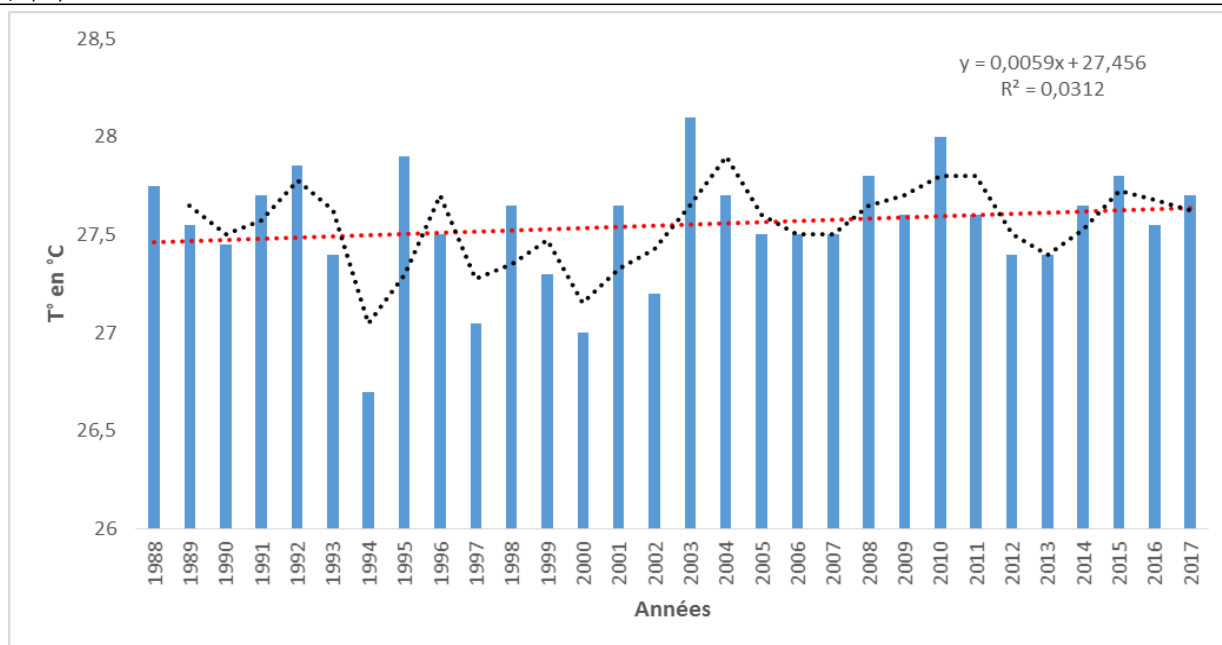


Figure 2: Annual average temperatures from 1988 to 2017

Gradual Warming Of The Climate

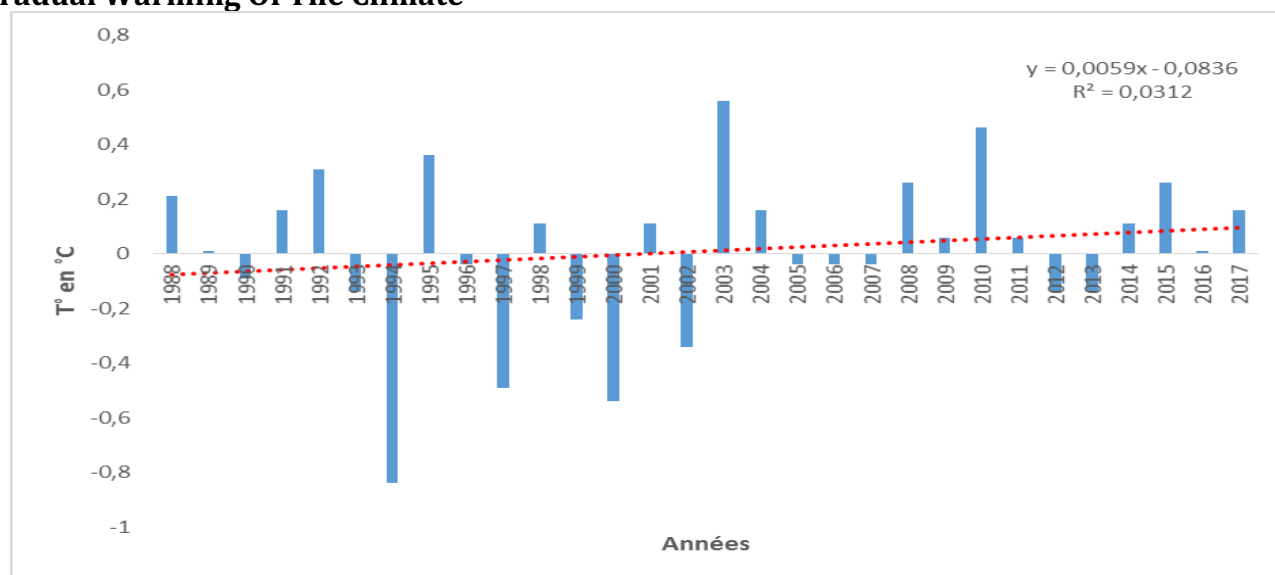


Figure 3: ACR of the inter-annual temperature averages

This figure 3 shows that the remarkable trend over the past 30 years has been a gradual and continuous increase in temperatures in Kélo. This confirms the work of IPCC (2016) which demonstrated that the earth's climate is warming more.

Irregularities In The Rains At The Start Of The Crop Year

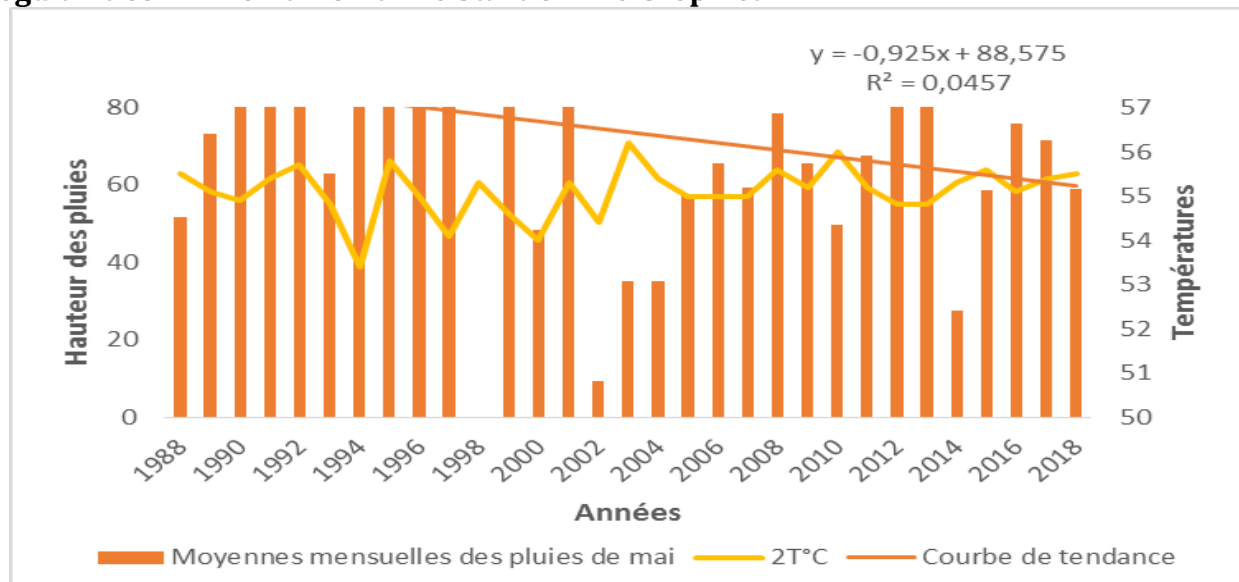


Figure 4: Monthly averages of May rains (1988 to 2018)

This figure shows the irregularities in the rains at the start of the crop year, that is to say in May. It is carried out on the basis of Gaussen theory ($P = 2T$). The observation of this figure distinguishes the years of good and bad distribution of the rains. From 1988 to 2002, the rains were very regular at their beginning, because only 3 years out of 15 were irregular. Rainfall is recorded at less than twice their temperature. From 2018 to 2003, the rains become more and more irregular at their beginnings, because the number of irregular years is almost equal to that regular and only 2 years out of 15 recorded 100mm of rains in May. The trend line highlights the regular decrease in rainfall in May depending on the year.

Irregularities In The Rains At The End Of The Precipitation Season

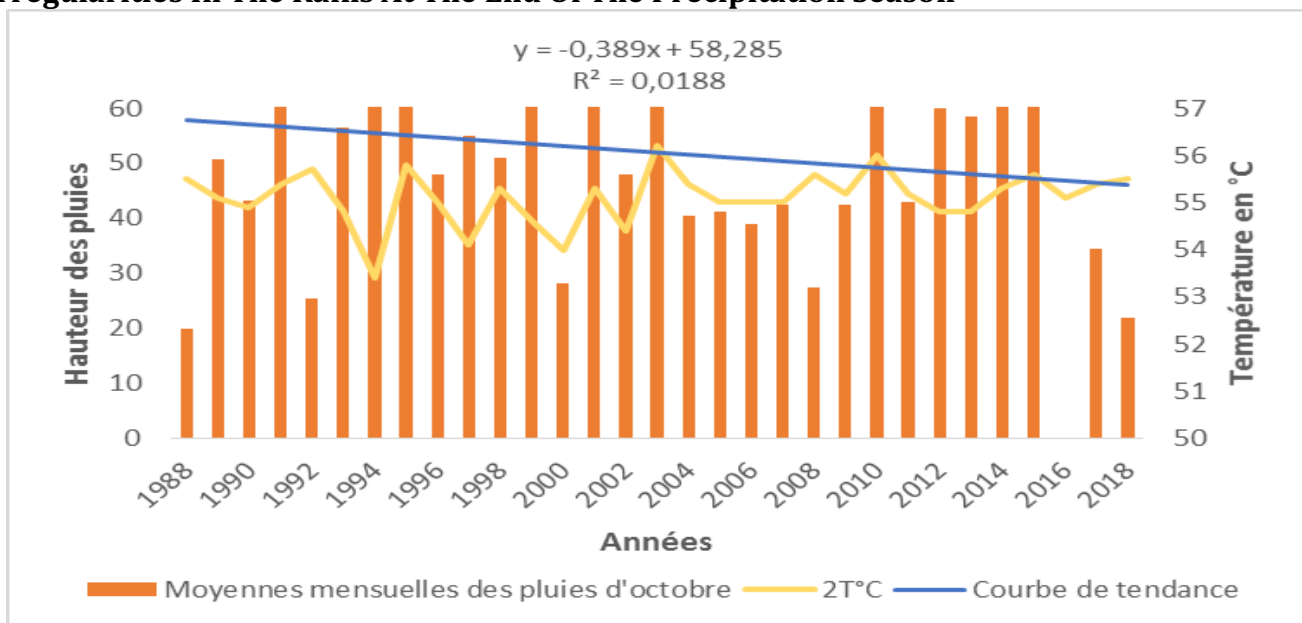


Figure 5: Monthly averages of October rains (1988 to 2018)

This figure shows the early or late end of the rains depending on the year. It is by the same method, that is to say Gaussien's theory that this figure was produced. The observation of this graph shows that the rains become more and more rare or irregular at the end of the rains in recent years.

Over the past 30 years, it has been observed that only 13 years have recorded rainfall greater than or equal to twice the temperature in October. From 1988 to 2003, 6 out of 16 years had a rainfall greater than or equal to twice the temperature in October. On the other hand, from 2018 to 2004, only 5 years out of 16 recorded rainfall more than double the temperature in May. Furthermore, the trend line shows that the rains have been decreasing regularly in recent years in October.

Interannual Variations In Rainfall

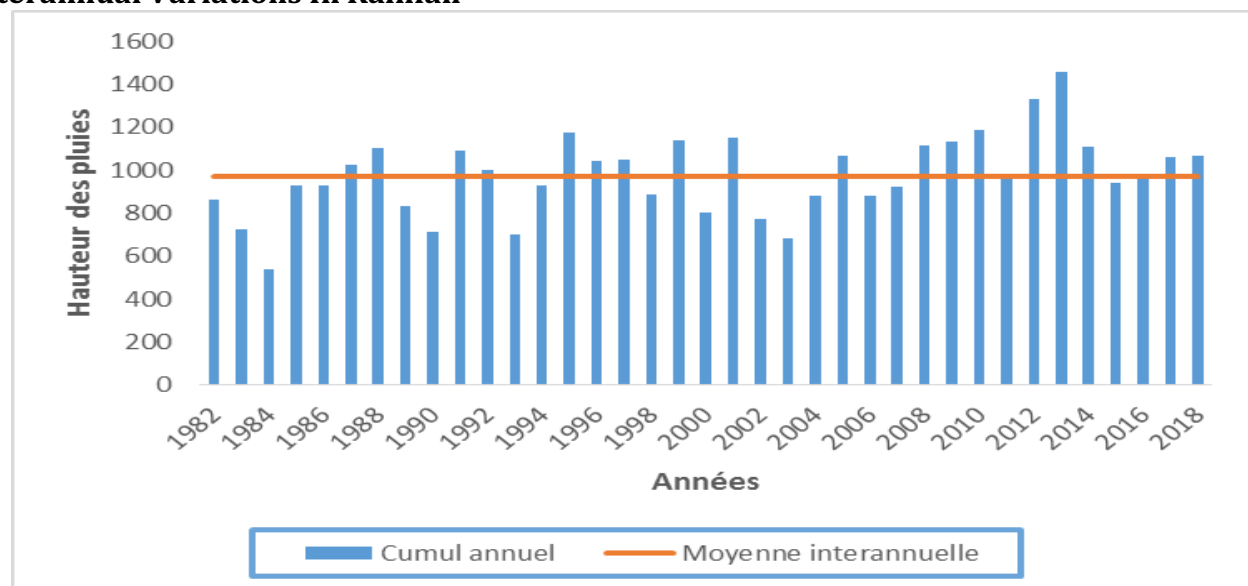


Figure 6: Annual averages of rains from 1988 to 2018

This figure 6 explains the interannual variations of the rains. The observation of this figure highlights the deficit years corresponding to years of drought, the surplus years which are in particular years of great floods and years of good rainfall. From 1982 to 2001, there were 6 deficit years, 3 surplus years and 11 years of good rainfall. On the other hand, from 2002 to 2018, there were 2 deficit years, 5 surplus years and 11 years of good rainfall. The years of drought and great flood are the real factors limiting agricultural production and therefore resulting in low household income leaving the farmers in a dynamic of poverty

Regular Increase In Annual Rainfall Totals

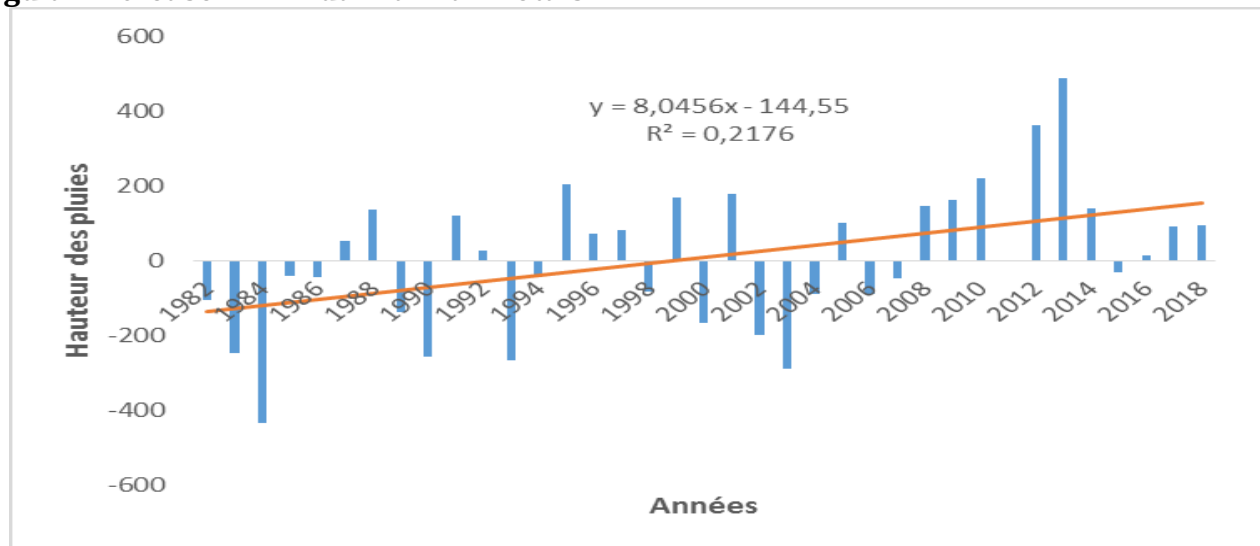


Figure 7: ACR of annual rainfall totals (1982-2018)

This figure shows an alternation between deficit years and surplus years, but it is difficult to know the evolution of the rainfall in Kélo. The observation in Figure 7 indicates that the rains have become more and more abundant in recent years as shown by the trend curve, contrary to the peasant perception on the ground.

The two (2) trend lines in Figure 4 and 5 show that the wet season has narrowed further in recent years. This narrowing is clearly seen in Figure 6. However, that of the reduced center anomalies in precipitation shows the year-to-date increases further. In other words, there has been a high rainfall in recent years, not spread over time but only over a very short period as shown in Figure 8. This means that the annual cumulation does not condition agricultural production in the Sudanian zone. This irregularity will cause farmers to turn to irrigation techniques by canalization in the shallows or by manual irrigation of crops.

Distribution of rains in the wet season

It is the main factor influencing the productivity of peasant agriculture in the Sahelo-Sudanian zone of Chad. The analysis in Figure 8 allows us to understand how the rains have spread in time in Kelo.

This curve shows that the rainy season begins in Kélo in March and ends in November. Each rainy month does not receive the same amount of rain. In July, there is a significant drop in rainfall. This is due to a long interruption of the rains at the start of this month, the dry sequence. According to Gaussen's theory ($P = 2T$), useful rain, that is to say the real wet season begins from May to September, five (5) months with an average annual volume of 986mm. However, the greatest amount of rain is concentrated only over a short period from June to September, that is to say only four (4). Finally, we realize that the rains fall more abundantly in recent years, but they are concentrated only for a small period during the year. This often causes large floods leading to the decay of plants thus putting farmers in a food insecurity.

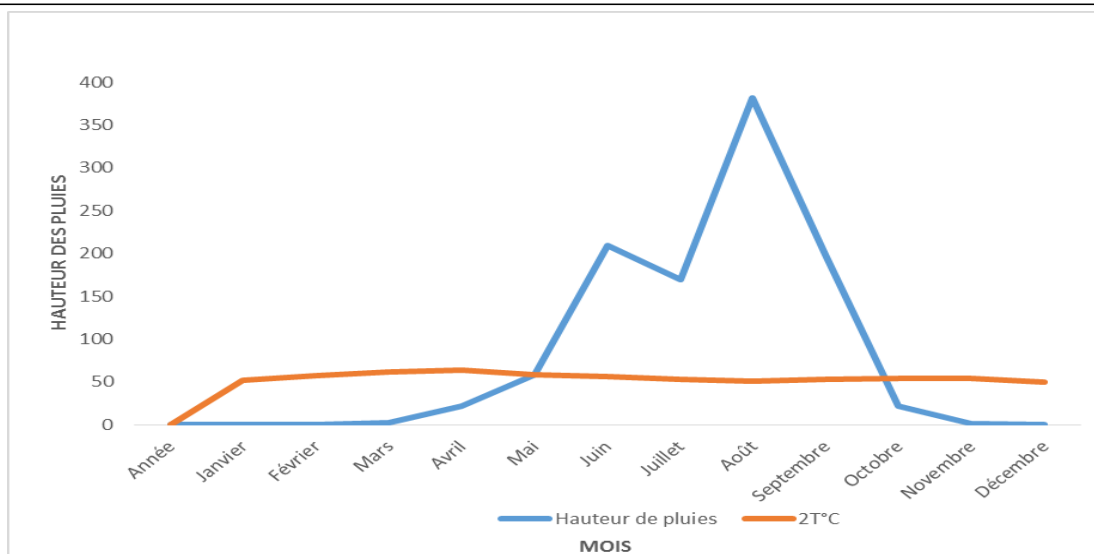


Figure 8: Ombrothermal curve of the monthly means of the Kélo station from 1982 to 2018
Source: Kélo meteorological station

Correlations Between Precipitation And Temperatures

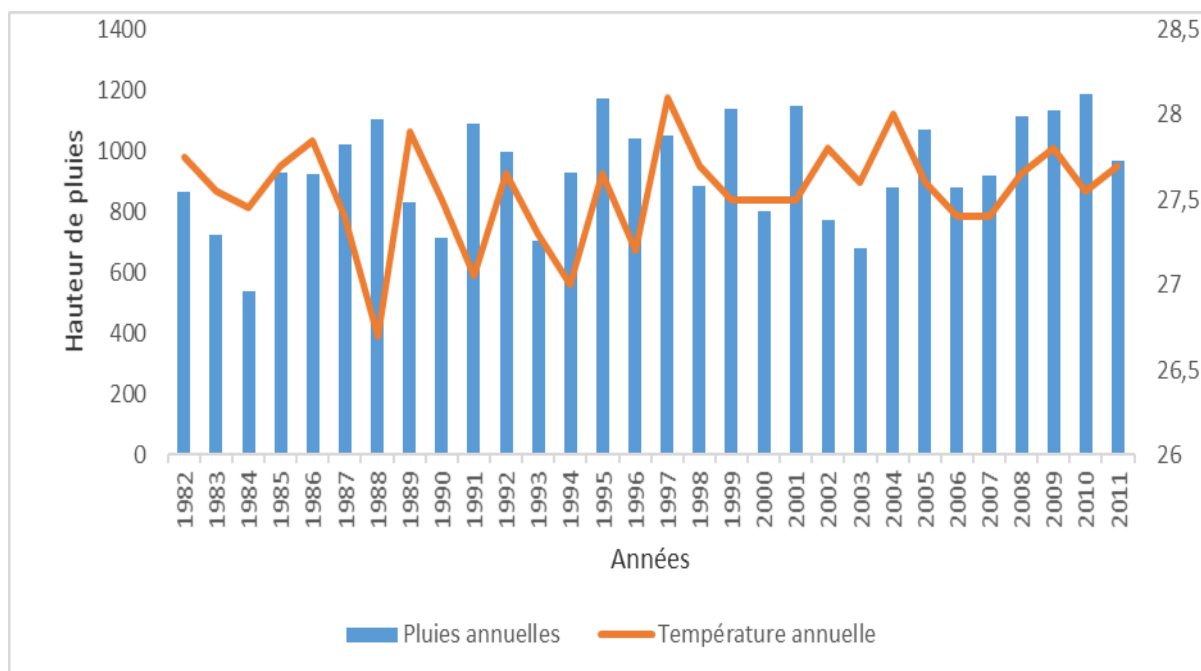


Figure 9: Correlations between precipitation and temperatures

Figure 9 shows the relationships between precipitation and temperature over the years. The figure shows that the hottest years correspond to the years of severe drought, while the years where the temperatures are very low, are the years most affected by the rains. This explains why precipitation attenuates heat through the humidity it brings. On the other hand, we also notice that after a warm period, comes a wet period, and after humidity, comes the heat and so on. It follows from these analyzes that there is a close relationship between temperature and precipitation. This relationship can be translated into the following property: "heat attracts rain and the abundance of rain activates

heat". We can deduce that the temperature considerably influences the rain mechanisms in the intertropical zone.

These results confirm the work of the researchers: Bangabutu D. X. (2007), Wakponou A.; Watang F. and Gonne B. (2007); Tsalefac et al (2006) who point out that climate change has brought about significant changes in the rainfall regime, the start and end dates, as well as the length of the growing periods. It is in particular these rainfall and thermal irregularities that disrupt agricultural activities.

Impact Of Climate Variability On Agricultural Activities

These most restrictive climatic vagaries in the study area include floods and droughts which are caused by rainfall irregularities. These two climatic hazards have a very negative influence on agriculture and animal husbandry, the main activities of populations, the arrival of desert locusts, plants rotting, plants often being recorded, loss of animals and large drop in grassy fodder . We also note the intense heat and the not insignificant changes in the rainfall regime, the start and end dates, as well as the duration of the growing periods which disrupt agricultural activities. The table below summarizes all the impacts of climate variability on agricultural activities in Kélo.

Table 1: Impacts of climate variability on agricultural activities

N°	Major climatic upheavals	Consequences
01	Rain delay with interruption and high heat	Melting of seedlings and rotting of sown seeds, grassing of plots and proliferation of enemies of culture
02	Early start of rains with early flooding	Invasion of the shallows or swallowing of young plants (rice, corn, sweet potato ...).
03	Prolonged interruption of the rains	- Slow growth of crops which end up becoming fragile. - Multiplication of crop enemies: striga, caterpillars, insects, etc.
04	Late start with early end of the rains	- Production of poorly developed ears and seeds - Fading leaves, melting flowers and producing sterile ears of corn
05	Degradation and impoverishment of the soil	Slow growth of crops and production of poorly developed ears and seeds
06	Intense heat	Drying of surface water and shortage of pasture
07	Arrival and massive sedentarization of breeders	Devastation of fields and conflicts

The consequences of the variability lead to the disruption of the agricultural calendar and a significant reduction in the yields of the main cultivated plants.

Comparison of the agricultural calendar and drop in crop yields in Kélo between 1988 and 2018

Tableau 2 : Agricultural calendar for 1988

Month / Activities	J	F	M	A	M	J	J	A	S	O	N	D	Yields
Cotton													600-900kg/ha
Mil, Sorghum													300- 500kg/ha
Peanut													800-1200kg/ha
Maize													900-1500kgs/ha
Sesame													300-400kg/ha
Bean													300-400kg/ha
Rice													1000-1500kg/ha
Cassava													4000-5500kg/ha

Table 3: Agricultural calendar for 2018

Mois/Activités	J	F	M	A	M	J	J	A	S	O	N	D	Yields (ha)
Cotton													400-600kg/ha
Mil, Sorghum													200- 300kg/ha
peanut													600-900kg/ha
Maize													800-1200kgs/ha
Sesame													150-250kg/ha
Bean													150-250kg/ha
Rice													900-1200kg/ha
Manioc													3500-4500kg/ha

Source : Field investigation

1	2	3	4	5
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Legend: 1 = Free time, 2 = Field preparation, 3 = Sowing, 4 = Field maintenance, 5 = Harvest

These two (2) tables show the beginnings and ends of agricultural activities, as well as the yields of the main cultivated plants for two (2) consecutive periods (1988 and 2018). In 1988, the agricultural calendar was very spread out over time. Farmers spent more of their time in agricultural activities (barely 1 or 2 months) with high yields (table). But in 2018, following the climatic upheavals, the agricultural calendar varied. Farmers spend more time in crafts (3 to 4 months) and there is a low crop yield of around 200 to 300 kg / ha. Thus, the popularization of improved seeds by the ministry in charge of the rural world and the adaptability of new varieties of cereals with short vegetative cycles by farmers.

Evolution Of Agricultural Production

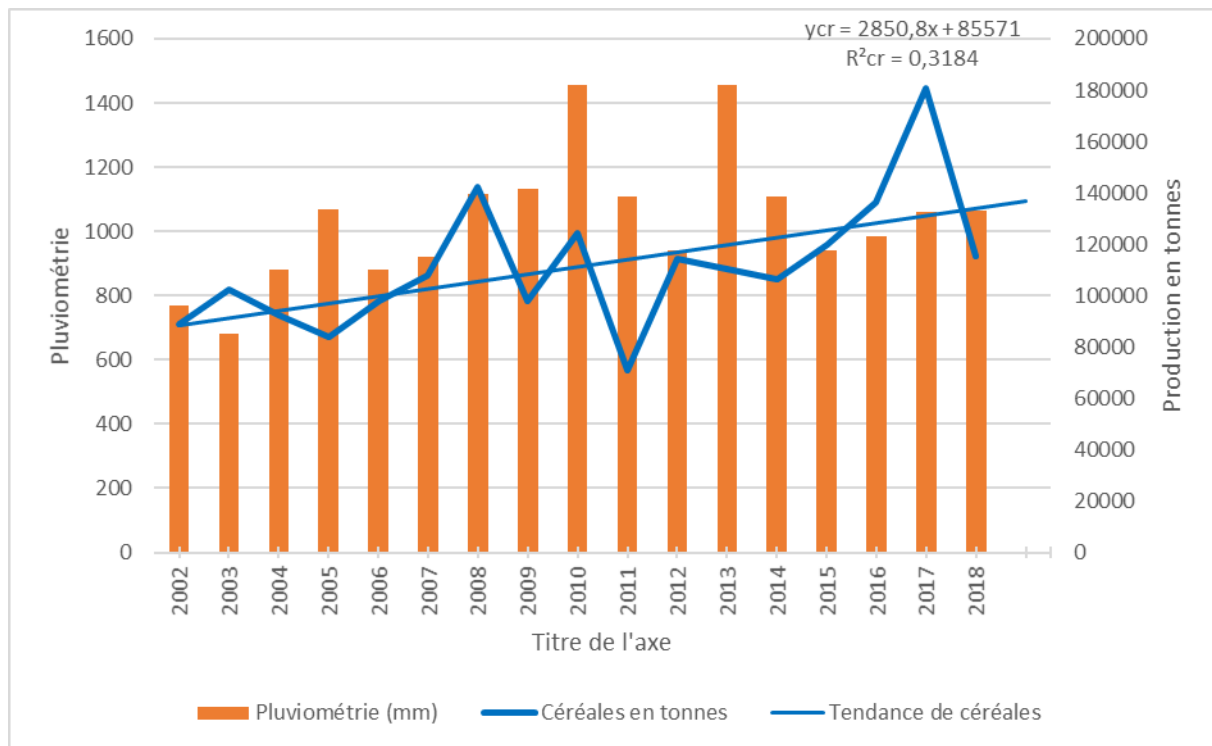


Figure 10: Evolution of cereal production in Kélo from 2002 to 2018

Source: ANADER of Kélo

This figure 10 is a correlation between annual rainfall and cereal production. It shows that there are no explicit linear relationships between these two (2) parameters. We notice sometimes that, when the rainfall increases, the cereal production decreases and sometimes, when the rainfall decreases, the cereal production increases or even when the rainfall increases, the cereal production also increases. So in 2004, 2005, 2009, 2011, 2013 and 2014 the annual rainfall is increased, but the cereal production is not of good quality. But for the rest of the years, cereal production obeyed the annual rainfall. This shows that knowledge of annual rainfall alone is not enough to explain the evolution of agricultural production (Bedoum, A., et al., 2014; Bazin, F., et al., 2013). This discrepancy can be explained by the poor distribution of rain during the wet season. But the remarkable overall trend is the gradual increase in cereal production. This latter situation can be explained either by the increase in the populations of farmers, or by the improvement of the technical and material conditions of production (ITRAD, 2020)

The Cereal Balance At Kelo

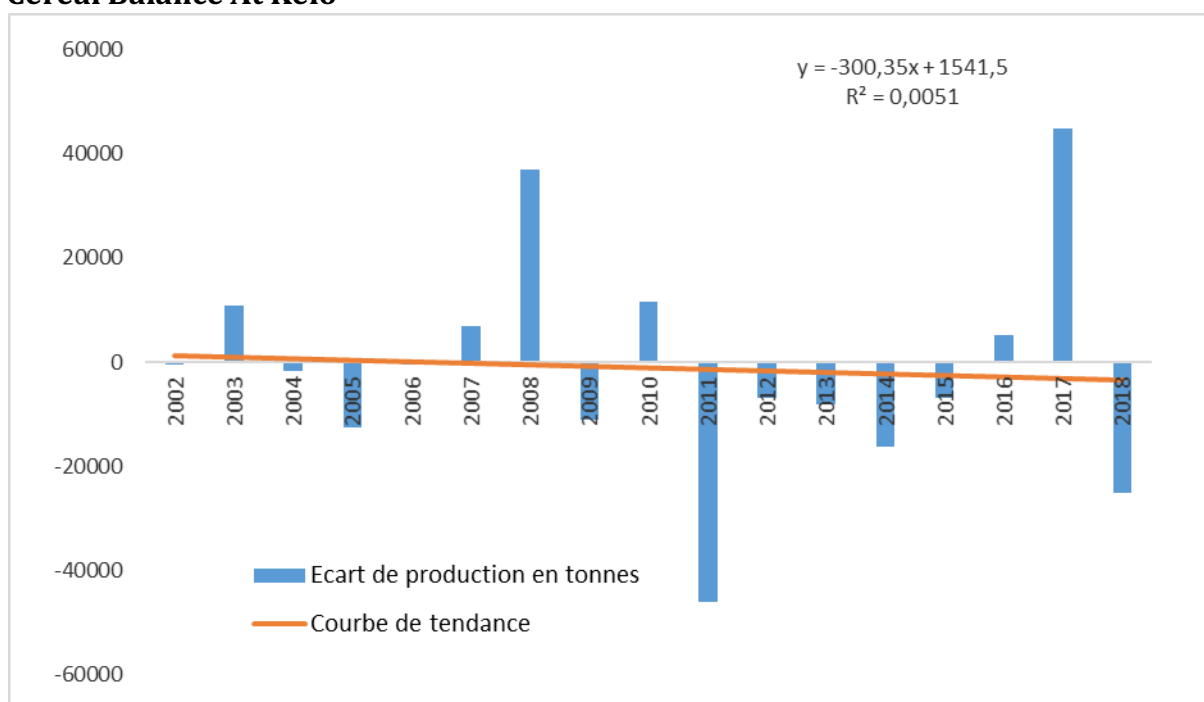


Figure 11: Cereal balance sheet of Kélo from 2002 to 2018

Source: ANADER of Kélo

Figure 11 shows the evolution of the cereal balance at Kélo. the balance sheet, which was in surplus, has become more and more negative lately. Before 2003, the cereal balance was positive, that is to say that the production of cereals greatly exceeded the consumption capacity of the population. From 2003 to 2008, this production still allowed food self-sufficiency. But from 2009, peasant agriculture does not manage to cover the food needs of the population of Kélo which confirms the work of Magrin, G. in 1996. This shows that the substantial increase in the production of cereals noted in Figure 9 is due only to the increase in the producer population and not to the increase in household production.

CONCLUSION

This study highlights the impacts of climate variability on peasant agriculture. The results show that the variation of the climate is marked during the year by a succession of dry season and wet season and, the alternation between a cold period and a hot period. During the wet season, the irregularities of the rains which result in late or early beginnings and ends, the appearance of dry sequences and also by the succession of deficit years and surplus years. But the remarkable trend is the gradual warming of the climate, the shortening of the wet season and the gradual increase in annual rainfall. The evaluation of the consequences of these climatic upheavals have modified agricultural calendars (sowing and harvesting dates), lower yields and production per household. It follows from this study that, due to climatic variability, peasant agriculture can no longer satisfactorily cover the increased needs of producers.

Despite the resilience strategies developed by the farmers, the latter remain dependent on the vagaries of the weather which further impoverish them. In addition, this dependence, with the

growing demography and the dynamics of poverty, not allowing them access to technological adaptations (mechanization, fertilizers, irrigation), constitute aggravating factors on the socio-economic impacts of the climate throughout the region.

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