EJSIT
European Journal of Science, Innovation and Technology
ISSN: 2786-4936
www.ejsit-journal.com
Volume 3 | Number 4 | 2023

Perception of Extreme Climatic Events on Bananas around the Petit Balè Dam in the Boromo Commune (Burkina Faso)

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ABSTRACT

The aim of this study is to analyse local extreme weather events and their impact on the banana sector, as perceived by small-scale producers in the village of Lapara, in the municipality of Boromo. To do this, primary data was collected using a survey method. One hundred producers were interviewed in the field using questionnaires. The study showed that small banana growers have a wide range of socio-demographic and socio-economic characteristics. They perceive rainfall extremes (R95P, SDII, CWD, R10mm) and temperature extremes (TXx). The study also showed that climate extremes lead to problems such as reduced banana quality, lower producer incomes, loss of banana production and a reduction in the area planted along the main river bed. It is therefore important that local authorities adopt proactive strategies to help growers cope with climatic extremes.

Keywords: Burkina Faso, extreme climatic events, smallholder banana producers

INTRODUCTION

Studies on climate change and agricultural production are well established. The impact of climate change on agricultural production has been observed in Africa (Barrios et al., 2008; Blanc, 2012; Ochieng et al., 2016), Europe (Olesen et al., 2011; Alexandrov & Eitzinger, 2005), Asia (Aryal et al., 2020, Mendelsohn, 2014) and the Americas (Adams et al., 1998; Isik & Devadoss, 2006). The impact is felt on productivity (Ayinde et al., 2011; Lobell & Gourdji, 2012; Ozdemir, 2021) and soil fertility (Ramankutty et al., 2002; St. Clair & Lynch, 2010).

This situation has led many farmers around the world to turn to fruit production, such as bananas, as a coping strategy (Zhu et al., 2021). Several countries in sub-Saharan Africa, notably Burkina Faso, have also started to produce bananas near various dams. Today, bananas rank third in fruit production, after mangoes and citrus fruits in Burkina Faso (Ministry of Agriculture and Amenagements Hydraulics, 2016). Many regions, including the Boucle Mouhoun region, have invested in banana production. This has enabled producers in Boromo to generate financial resources ranging from 135,000 FCFA to 3,125,000 FCFA (Yaméogo et al., 2022). Burkina Faso is also subject to climatic variability, manifested by variations in climatic variables (rain, temperature, wind, evapotranspiration) (Lodoun et al., 2013; Ibrahim et al., 2014).

Moreover, recent rainfall patterns (1990-2020) are also characterized by the occurrence of extreme rainfall events (Yanogo & Yaméogo, 2023). In this context, the following research question can be justified: are small banana growers affected by extreme climatic events in Burkina Faso? The main objective of this study is to analyse local extreme climatic events and their impact on the banana sector, as perceived by small-scale producers in the village of Lapara, in the Boromo commune. The aim is to identify the socio-economic characteristics of small-scale producers, to analyse their perceptions of extreme climatic events and the problems they cause.

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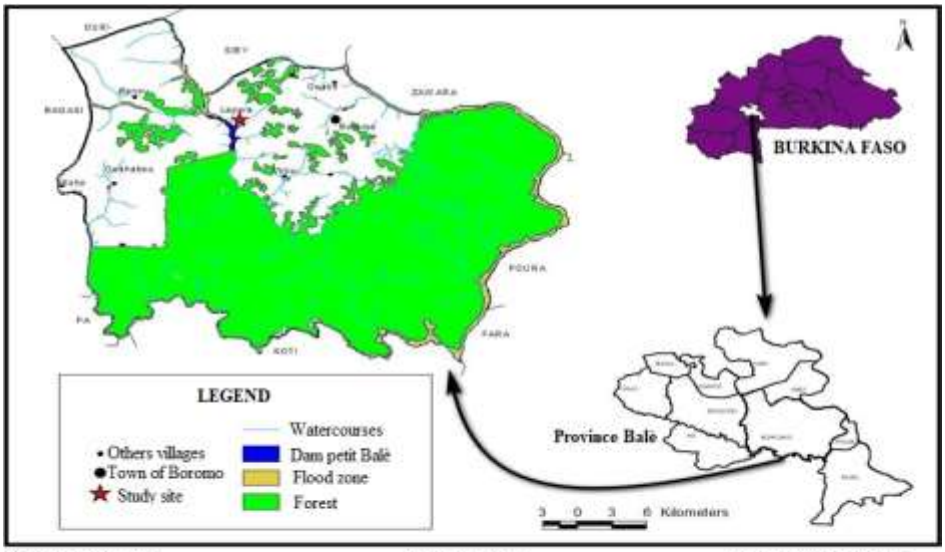
REVIEW OF THE LITERATURE

There are numerous studies on climate extremes in world. They focus on trend analysis of climate extremes (Ajjur & Riffi, 2020; Abbasnia & Toros, 2020), on the impacts of climate extremes on ecosystems (Christensen et al, 2021; Sabater et al., 2023), food security (Gbegbelegbe et al., 2014; Lesk et al., 2016; Pagani et al., 2017; Hasegawa et al., 2021) and health (Mason et al., 2020; Ebi et al., 2021). Moreover, most studies on climate extremes (Costa et al., 2020; Dos Reis et al., 2020; Shawul & Chakma, 2020; Pervin & Khan, 2022; Ryan et al., 2022) use the indices defined by the World Meteorological Organisation (WMO) in the framework of the CC/CLIVAR Expert Team on Climate Change Detection, Monitoring and Indices (ETCCDMI) using the RclimDex software (Zhang & Yang, 2004). In Sub-Saharan Africa (SSA), the impacts of climate change and extreme weather events are becoming more intense and frequent (Ayanlade et al., 2022). Thus, most studies focus on characterising climatic extremes (Nangombe et al., 2018; Adeyeri et al., 2019), farmers' adaptation strategies to climatic extremes (Boansi et al., 2017; Owusu & Yiridomoh, 2021). However, very few studies (Yiridomoh et al., 2021) have focused on farmers' perceptions of extreme weather events and their impact on production activities. However, understanding local people's perceptions of extreme rainfall events and their variability is essential for reducing the natural risks associated with extreme events (Eini et al., 2022). It is therefore appropriate to address this issue in order to fill this gap in studies on climate extremes.

DATA AND METHODS

Presentation of the Study Area

The study site is located in the Boucle du Mouhoun region, in the Balè province (Figure 1).



Source : BNDT, 2014 Date:10/01/2021 Author: Yaméogo Joseph

Figure 1. Localization of study site

The region has a Sudano-Sahelian climate, with an alternating dry season (November to May) and rainy season (June to September-October), with maximum rainfall in July and August (Yaméogo et al., 2022).

Data Collection Methods

They are based on field surveys. Indeed, in the study area, a survey was carried out over a period of four (04) months (January-April 2023). The population concerned by the study was the banana producers around the Petit Balè dam, in the village of Lapara, in the commune of Boromo. 50% of the banana growers were involved in the study, i.e. 100 banana growers in the study village. The surveys focused on the perception of extreme rainfall events, their impacts on banana producers. The extreme climate indices that the farmers have to face are listed in Table 1.

Table 1. Producer-reported climate index extremes

Element	Index	Definition according to the Expert Team on Climate Change Detection, Monitoring and Indices (ETCCDMI)	Definition as provided by the banana growers	Unit
Temperature	TXx	Annual maximum temperature	Very high temperature	°C
	TXn	Annual minimum temperature	Low temperatures	°C
Precipitation	R1mm	Number of days with rainfall ≥ 1 mm	Waterlogging of the ground for a few minutes	day
	R10mm	Number of days with rainfall ≥ 10 mm	Heavy run-off of rainwater for several hours	day
	R20mm	Number of days with rainfall ≥ 20 mm	Seedlings are underwater for several days	day
	SDII	Simple daily intensity index	Heavy rain (with wind and for a long period of time)	mm/day
	CWD	Consecutive wet days	Flooding of the major bed of the Petit Balè dam for several days	days
	R95p	Very wet days	Heavy rain (associated with large quantities of water)	mm

Source: Gnjato et al., 2021; Field surveys, January-April 2023

Data Processing Methods and Analysis

The methods used to analyse the primary data consist of calculating: the index of occurrence of extreme climatic events, ordinal logistic regression, and the problem confrontation index.

Index of relative importance of extreme climatic events (IRIECE)

The assessment of climatic extremes makes extensive use of importance index methods (Ndamani & Watanabe, 2017; Likinaw et al., 2022; Liu et al., 2022) whose formula is (Kassem et al., 2020):

$$IRIECE = \frac{\sum W}{A * N} \tag{1}$$

Where N is the total number of respondents; A is the highest weight (1….3): W is the weight assigned to each factor by respondents on the Likert scale shown in Table 2.

Table 2. Response categories and their weight

Response	Weight
Very common (VF)	3
Frequent (F)	2
Uncommon frequency (UF)	1
Frequency Unimportant (FU)	0

Source: Adapted from Abd El-Razek et al., 2008

Ordered logit model (OLM)

The perception of extreme weather events is recorded on a Likert ordinal scale. The ordered logit model (OLM) is therefore used to capture the factors that determine banana growers' perceptions of extreme weather events. The purpose of this model is the prediction of relationships between independent variables and perceptions of the types of extreme weather events. The dependent variables are the types of extreme climate events perceived by farmers, and the independent variables are socio-economic characteristics (age, gender, level of education, distance from the dam and income level). The ordinal logistic model used in this study is as follows (Ehsan et al., 2022):

$$Logit\ Y = in\left(\frac{prob\ (cat. \leq j}{prob\ (cat. \geq j}\right) = \alpha_i + \left(\beta_i \times X_I\right) \tag{2}$$

Where, Y represents the types of extreme climate events perceived (with Very frequent (3), Frequent (2), Infrequent (1), Unimportant (0)), *j* represents the categories of the ordinal dependent variable and j -1 is the cumulative logit, α is the constant, β is the parameter and xi is a set of independent variables (binary and/or continuous).

Problem confrontation index

The problems faced by producers after the occurrence of extreme climate events are expressed through the Problem Confrontation Index (PCI), which is a measure for identifying problems and constraints that are tabulated according to their severity (Kabir et al., 2019). several studies (Hossain et al., 2011; Roy et al., 2013; Mithun et al., 2018; Popoola et al., 2020; Antwi-Agyei et al., 2021) use the index to elucidate the problems encountered by respondents, whose formula is as follows (Pickon & He, 2021):

$$PCI = \left(P_H \times 3\right) + \left(P_M \times 2\right) + \left(P_L \times 1\right) + \left(P_N \times 0\right) \tag{3}$$

Where, PCI= problem confrontation index, P_H = number of producers finding the problem high, P_M = number of producers finding the medium problem, P_L=number of producers finding the low problem, P_N= number of producers finding no problem. The response options were placed on a Likert scale as follows: high, medium, low, and not at all. The scores assigned to the responses were 3, 2, 1, and 0 respectively.

RESULT AND DISCUSSION

Perception of Extreme Climatic Events and Factors of Influence

Socio-economic and demographic characteristics of banana growers

Banana growers have a wide range of socio-economic and sociodemographic characteristics (Figure 2).

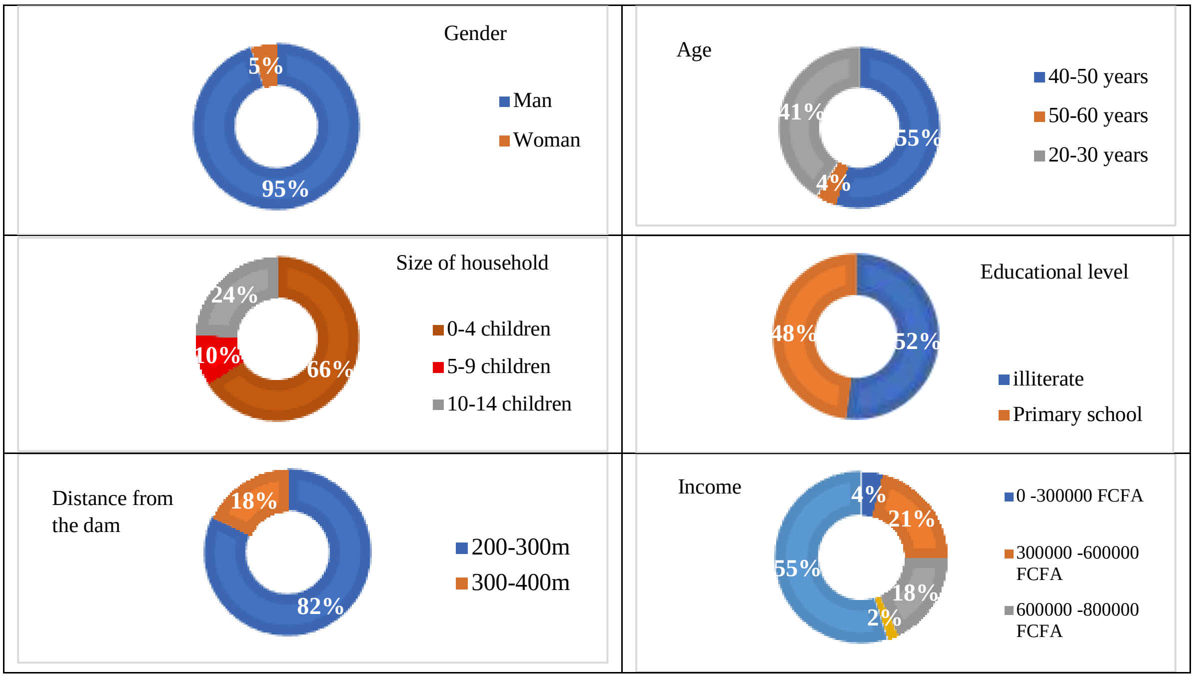


Figure 2. Socio-economic and demographic characteristics

The figure shows that 95% of the sample were men, with 55% in the 40-50 age bracket, 41% in the 20-30 age bracket and 4% in the 50-60 age bracket. 52% of respondents were illiterate, compared with 42% who had attended primary school. 55% of respondents have an annual income of between 0 and 300,000 CFA francs, compared with 21% who earn between 300,000 and 600,000 CFA francs. 82% of respondents have plots of land between 200 and 300 meters from the Petits Balè dam.

Perception of extreme climatic events

Table 3 shows that farmers' perceptions are based on heavy and intense rainfall (R95P, SDII, R1mm, R10mm, R20mm, CWD). As far as temperature is concerned, the scorching nature of the temperatures (TXx) is revealed by producers.

Table 3. Producers' perceptions of climatic extremes

Extreme climatic seen by producers	**Very frequent (3)**	**Frequent (2)**	**Infrequent (1)**	**Unimportant (0)**	**IRIECE**	**Rank**
			Rain			
Heavy rain (associated with large quantities of water) (R95P)	45 (26.68%)	130 (68.42%)	15 (7.90%)	0 (0%)	63.33	2rd
Heavy rain (with wind and for a long period of time) (SDII)	105 (51.23%)	90 (43.90%)	10 (4.88%)	0 (0%)	68.33	1st
Waterlogging of the ground for a few minutes (R1mm)	9 (7.56%)	80 (67.23%)	30 (25.21%)	0 (0%)	39.66	6th
Heavy run-off of rainwater for several hours (R10mm)	0 (0%)	86 (71.07%)	35 (28.92%)	0 (0%)	40.33	5th

Flooding of the major bed of the Petit Balè dam for several days (CWD)	9 (5.23%)	134 (77.91%)	29 (16.86%)	0 (0%)	57.33	3th
Seedlings are underwater for several days (R20mm)	21 (12.28%)	120 (70.17%)	30 (17.54%)	0 (0%)	57	4th
Temperature						
Seedlings wither as temperatures rise in the dry season (TXx)	180 (72%)	60 (24%)	10 (4%)	0 (0%)	83.33	1st
During the dry season, the water in the dam is so hot that fish are scarce (TXx).	150 (63.83%)	80 (34.04%)	5 (2.13%)	0 (0%)	78.33	2rd

Source: Field surveys, January-April 2023

This table shows that the first extreme rainfall event affecting bananas considered by producers is the SDII, R95P, CWD) with IRIECE 68.33, 63.33 and 57.33 respectively. This was followed by R20mm, R10mm and R1mm. The occurrence of scorching temperatures (TXx) during the dry season is considered an extreme temperature by producers. In addition, 68.42% of farmers stated that R95P was frequent during the period 1991-2021. SDII is very frequent and frequent with 51.23% and 43.90% of banana growers respectively. R10mm and CWD are also frequent according to growers. Torrid temperatures were observed very frequently by banana growers during the 1991-2021 period.

The perceptions of banana growers near the Petit Balè dam are also reported by several authors in Burkina Faso. De Longueville et al (2015) note that extreme rainfall (SDII, R10mm, R20mm, PXJA) is increasing in Burkina Faso. This finding is confirmed by Yanogo and Yameogo (2023), since the occurrence of extreme rainfall (total wet days (rainfall ≥1 mm) (JP), frequency of intense rainfall (P95 (day), intensity of rainy days (SDII (mm/day), maximum daily rainfall (PXJA (mm))) was observed between 1990 and 2020. Romero et al (2011) also report an increase in maximum temperatures, which could lead to an increase in the country's evapotranspiration potential. This increase in precipitation extremes is a global trend in West Africa between 1961 and 2010. In fact, most West African countries were also affected by the emergence of extreme indices during this period (1961-2010) (Barry et al., 2018).

Socio-economic factors influence perceptions of climate extremes

The perceptions of smallholder banana growers depend on socio-economic characteristics. The perception of extremes such as Heavy rain (associated with large quantities of water) (R95P), Heavy rain (with wind and for a long period of time) (SDII) depends on the income level and age of the growers. For the case of Flooding of the major bed of the Petit Balè dam (CWD), seedlings underwater for several days (R20mm), age, household size and distance from the dam influence these rainfall extremes. As for the wilting of the plants with the increase of the dry season temperatures, the size of the household, the age and the level of education have an effect on the extreme temperature index. Tables 4, 5 and 6 below show in detail the factors influencing the perception of climate extremes.

However, other studies do not fully support the findings regarding the influence of socio-demographic factors on the perception of climate extremes. In Ghana, Yiridomoh et al. (2021) found that gender influences climate risk perception, with women more likely to perceive climate extremes. Abuloye and Moruff (2016) came to the same conclusion in Nigeria. However, in this study, gender did not influence the perception of climate extremes, which could be explained by the fact that few women were able to respond, unlike in Ghana and Nigeria where women made up almost the entire research sample. Furthermore, Lechowska (2018) notes that when climate extremes cause climate risks, such as flooding, the socio-economic and demographic factors of the population (gender, age, education, income, number of children) are particularly affected by the risk.

Other studies (Kellens et al., 2011; Wang et al., 2018; Liu et al., 2022) have concluded that the perception of flood risk is significantly correlated with age, marital status, education, monthly income, occupation, experience and distance from the dam.

Table 4. Regression result between R95P, SDII and socioeconomic characteristics

Heavy rain (associated with large quantities of water) (R95P)				Estimates of parameters		Heavy rain (with wind and for a long period of time (SDII)				Estimates of parameters	
				95% Confidence Interval						95% Confidence Interval	
		ddl	p-value	Lower Bound	Upper Bound			ddl	p-value	Lower Bound	Upper Bound
Threshold	[Heavy rain (associated with large quantities of water) (R95P) = 1]	1	.466	-5.379	2.461	Threshold	[Heavy rain (with wind and for a long period of time) (SDII) = 1]	1	.825	-4.337	5.438
	[Heavy rain (associated with large quantities of water) (R95P) = 2]	1	.371	-2.099	5.618		[Heavy rain (with wind and for a long period of time) (SDII) = 2]	1	.015	1.198	11.240
	[Heavy rain (associated with large quantities of water) (R95P) = 3]	1	.055	-.078	7.920						
Position	Age	1	.488	-.255	.534	Position	Age	1	**.002***	.330	1.423
	Household size	1	.498	-.129	.266		Household size	1	.252	-.471	.124
	Education level	1	.693	-.837	1.260		Education level	1	.057	-.038	2.578
	Distance to dam	1	.111	-.241	2.334		Distance to dam	1	.344	-2.111	.736
	Income level	1	**.005***	-.604	-.107		Income level	1	.054	-.006	.671

Note: *** p ≤ 0.001, **p ≤ 0.01; * p ≤ 0.05

Table 5. Regression result between CWD, R20mm and socioeconomic characteristics

Flooding of the major bed of the Petit Balè dam for several days (CWD)				Estimates of parameters 95% Confidence Interval		Seedlings are underwater for several days (R20mm)				Estimates of parameters 95% Confidence Interval	
		ddl	p-value	Lower Bound	Upper Bound			ddl	p-value	Lower Bound	Upper Bound
Threshold	[Flooding of the major bed of the Petit Balè dam for several days (CWD) = 1]	1	.308	-2.217	7,030	Threshold	[Seedlings are underwater for several days (R20mm) = 1]	1	.239	-1.657	6.650
	[Flooding of the major bed of the Petit Balè dam for several days (CWD) = 2]	1	.001	3.674	13,457		[Seedlings are underwater for several days) (R20mm) = 2]	1	.003	2.109	10.343
	[Flooding of the major bed of the Petit Balè dam for several days (CWD) = 3]	1	.000	6.635	17,410		[Seedlings are underwater for several days) (R20mm) = 3]		.000	3.957	12.531
Position	Age	1	**.001****	.426	1,545	Position	Age	1	**.013***	.105	.908
	Household size	1	**.009***	.094	,658		Household size	1	.787	-.168	.221
	Education level	1	.824	-1.103	1,386		Education level	1	.090	-.143	1.978
	Distance to dam	1	**.001****	1.057	4,335		Distance to dam	1	**.024***	.198	2.855
	Income level	1	.830	-.344	,276		Income level	1	.424	-.138	.328

Note: *** p ≤ 0.001, **p ≤ 0.01; * p ≤ 0.05

Table 6. Regression result TXx and socioeconomic characteristics

Seedlings wither as temperatures rise in the dry season (TXx)				Estimates of parameters 95% Confidence Interval	
		ddl	p-value	Lower Bound	Upper Bound
Threshold	[Seedlings wither as temperatures rise in the dry season (TXx) = 1]	1	.226	-1.653	7.011
	[Seedlings wither as temperatures rise in the dry season (TXx)= 2]	1	.006	1.839	10.859
Position	Age	1	**.035***	.033	.935
	Household size	1	**.023***	.038	.508
	Education level	1	**.035***	.090	2.554
	Distance to dam	1	.165	-2.461	.420
	Income level	1	.593	-.204	.357

Note: *** p ≤ 0.001, **p ≤ 0.01; * p ≤ 0.05

Problems Faced by Producers as a Result of Extreme Climatic Events

The occurrence of extreme weather conditions has caused problems for producers in the production and sale of bananas. The problems faced by small producers are listed in Table 7 below.

Table 7. The problems faced by small-scale producers

Problems	No problem (0)	Low problem (1)	Medium problem (2)	Problem high (3)	PCI	Rank
Banana production losses	0 (0%)	5 (2.32%)	150 (79.77%)	60 (27.91%)	215	1st
Reducing the surface area of parcels located close to the major bed of the Petit Balè dam	0 (0%)	30 (18.18%)	120 (72.72%)	15 (9.09%)	165	2rd
Decline in producers' incomes	0 (0%)	75 (74.26%)	20 (19.80%)	6 (5.94%)	101	4th
Increase in banana diseases due to the presence of water	0 (0%)	8 (100%)	0 (0%)	0 (0%)	8	6th
Decline in the quality of bananas	0 (0%)	60 (54.54%)	20 (18.18%)	30 (27.27%)	110	3th
Loss of banana seedlings	0 (0%)	15 (60%)	10 (40%)	0 (0%)	25	5th

Source: January-April 2023

The table shows that 79.77% of growers consider loss of production to be a medium problem, while 27.91% consider it to be a high problem. The loss of banana plantations is due to the rise in temperature, which causes the drying and yellowing of the banana leaves (Figure 3).

Figure 3. Banana leaves drying and yellowing after scorching temperatures in April 2023

In addition, some banana plants find it difficult to develop properly. Figure 4 below shows a stunted plant as a result of high temperatures.

Figure 4. Banana plants dying due to water stress caused by rising temperatures

This leads to lost bananas and therefore reduced productivity. Similarly, 72.72% of respondents had noted a reduction in the size of their plots, but considered this to be a medium problem. On the other hand, the reduction in income, the increase in banana diseases, the reduction in banana quality and the loss of banana plants were considered to be minor problems by producers.

The problems caused by climate extremes are confirmed by other studies. For Calberto et al. (2016), the impact of weather events causes problems for banana productivity and profitability worldwide, particularly in Africa. Varma and Bebber (2019), Karienye et al. (2021), Watts et al. (2023) report that increasing climatic parameters are lowering banana yields worldwide. This could be because high temperatures can damage the plant and fruit, while low temperatures slow growth and affect fruit quality (Ortiz, 2012). Noleppa et al. (2021) have identified other problems, such as the fall in banana prices and the impact on the incomes and profitability of producers in Latin American countries (Colombia, Costa Rica, the Dominican Republic, and Ecuador).

CONCLUSION

Climate extremes are a reality for small banana growers, as they perceive them in terms of both temperature and rainfall. However, producers' perceptions are influenced by socio-demographic and socio-economic characteristics. Extreme climatic conditions also have an impact on banana production (reduction in banana quality) and on farmers (loss of banana production, reduction in farmers' incomes). There is therefore an urgent need for the Boromo commune to help banana growers cope with the region's extreme climatic.

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