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Local Communautes' Perceptions of Climate Variability in the Sourgou Commune of the Boulkiemde Province: A Move from a Vulnerable to a Resilience-Based Stance

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Abstract For several decades, Burkina Faso, including other Sahelian countries, has been facing a number of climate-related issues. As a matter of fact, due to underdevelopment and inappropriate response strategies, the situation is worsening. This study, aiming at understanding the impacts of climate variability, was conducted in the commune of Sourgou in Burkina Faso. The approach consisted in analyzing climate data from surveys sampled with 422 agricultural households. Land use data from 1989, 2002 to 2019 were processed to better understand soil dynamics in the study area. Results revealed a change in the duration of the rainy season with a late start and an early end. It also included the variability of climate features and an increasingly recurrent occurrence of pockets of drought exceeding 10 days. The analysis of land use dynamics showed a regression of vegetation cover (18.26%), an increase in bare soil (15.75%), mixed crops (44.88%) and a decrease in single rainfed crops (45.64%). Adaptation strategies adopted range from soil conservation techniques such as the zaï technique (21.6%), stone cordons (67.1%), biological techniques such as mulching (31.5%) to mitigating adaptive activities such as irrigated farming (61.1%). Considering socio-economic, political and environmental issues raised in line with the adoption of the adaptation strategies, enormous efforts are to be made in developing common regulations and local adaptation techniques for farmers to consistently apprehend the issue.

Keywords: *climate variability, apprehension, adaptation strategies, resilience, Burkina Faso*

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1. Introduction

Over the world, climate change is more and more visible. It changes into different dimensions depending on the hemisphere and geographical locations [1]. Climate change is noticed in the world through various events such as cyclones, thermal expansion or melting of glaciers; but sometimes with devastating effects in Africa, experiencing droughts and/or floods [2]. Besides, it is associated with low and insufficient rainfall and recurrent drought [3]. Africa is one of the most severely-affected regions by climate change effects. Such effects include water stress, reduced agricultural yields, food insecurity and malnutrition, associated with rapid population growth having consequences on natural resources [4]. Sub-Saharan Africa is more affected by such effects as over 96% of the population life directly depend on rainfed agriculture [5].

In Burkina Faso, agriculture accounts for nearly 80%, or even 86% of the population [6], and the production system remain traditional and depend on rainfall [7]. According to [8], Burkina Faso is likely to suffer the adverse effects of climate variability because of its physical and socio-economic situation. Climate variability mostly affects rural populations due to their daily activities in natural environment. The rapid population growth and the vulnerability of the population has a direct impact on the available resources, which are deteriorating. Agriculture, in this form cannot cover the food needs of the population; moreover, it is still extensive and has been suffering the effects of climate change for a number of years [7]. Rain is an essential aspect for farmers in understanding the phenomenon of climate variability. Climate-related knowledge is therefore an important part of the strategies developed by populations to adapt to the impacts in the Sahel region [9]. In order for farmers to improve strategies and face the impacts caused by climate change, it is important to see how they view climate change and analyze the factors affecting this apprehension [10]. Considering recurrent and alarming climate crisis, organizations such as FAO, CILSS, including States, are carrying out activities to mitigate the effects of climate variability on farmers' agricultural activities. In fact, sometimes farmers are not enough equipped, and the techniques used for soil fertility or its restoration are inappropriate or poorly used [7,8,9,10,11]. Low investments, local populations' low involvement, and low knowledge of certain techniques by local communities sufficiently account for the vulnerability of rural households to climate variability. In this study, surveys, interviews, the use of climate and land use data have made it possible to better understand the issue of climate change and its effects. The perception of the local communities of Surgou corroborates with the scientific observation on the manifestations and the induced effects of the climate in recent decades (1988-2018). This paper is developed to examine local communities' perceptions of climate variability on the one hand, and to identify mitigation measures to cope with this climate variability on the other hand.

2. Materials et Methods

2.1. Study Area Location

With a land area of 266 square kilometers, the Sourgou commune is a rural one with around 13,709 inhabitants [6]. Sourgou is one of the 14 rural communes in the Boulkiemdé province. It is 15 km away from the provincial capital Koudougou and 10 km from the commune of Sabou on the national road no. 13 linking Koudougou to Léo, between longitude 12°30' N, and latitude 2°09' W. It is borded to the west by the commune of Laponais, the north by the commune of Koudougou and Ramongo, the south by the commune of Sabou, and the east by the commune of Poa (Figure 1).

The central-west region is located in the Sudano-Sahelian area with an average annual rainfall of 817 mm. The commune of Sourgou has a relatively flat relief, predominantly marked with several types of soils. However, lithosols on cuirass and ferruginous soils are the most common. Vegetation is a wooded savannah type covered with shrubs and dominated by species such as *Vitellaria paradoxa*, *Bombax costatum*, *Tamarindus indica*, *Parkia biglobosa*, *Acacia albida*, *Khaya seneglensis*, *Lannea microcarpa*, *Guiera senegalensis.* The herbaceous stratum consists of *Andropogon gayanus*, *Loudetia togoensis*, *Pennissetum pedicellatum.* Exotic trees such as *Azadirachta indica*, *Mangifera indica* and *Eucalyptus camaldulensis* can also be found. The commune of Sourgou has four water bodies. It is located in the international Volta Basin and the Mouhoun watershed within the country. The hydrographic system makes it difficult to have certain activities such as off-season farming. Agriculture is the main activity of Sourgou people.

2.2. Data Collection and Analysis

Questionnaires and interview manuals were the tools used for data collection. These are self-administered questionnaires and semi-structured interviews. Considering that age plays a major role in assessing experience, especially in assessing the apprehension of climate and agricultural production, target population included beyond 40 male and female producers. Agents from decentralized technical services of the country were interviewed. These services included environment, agriculture, livestock ones and the town hall with its related bodies. Elderly people and resource persons were also interviewed as they had witnessed the drought of the 1970s or other pockets of droughts and/or climatic crises that occurred in Burkina Faso. Data were collected from June to July 2020.

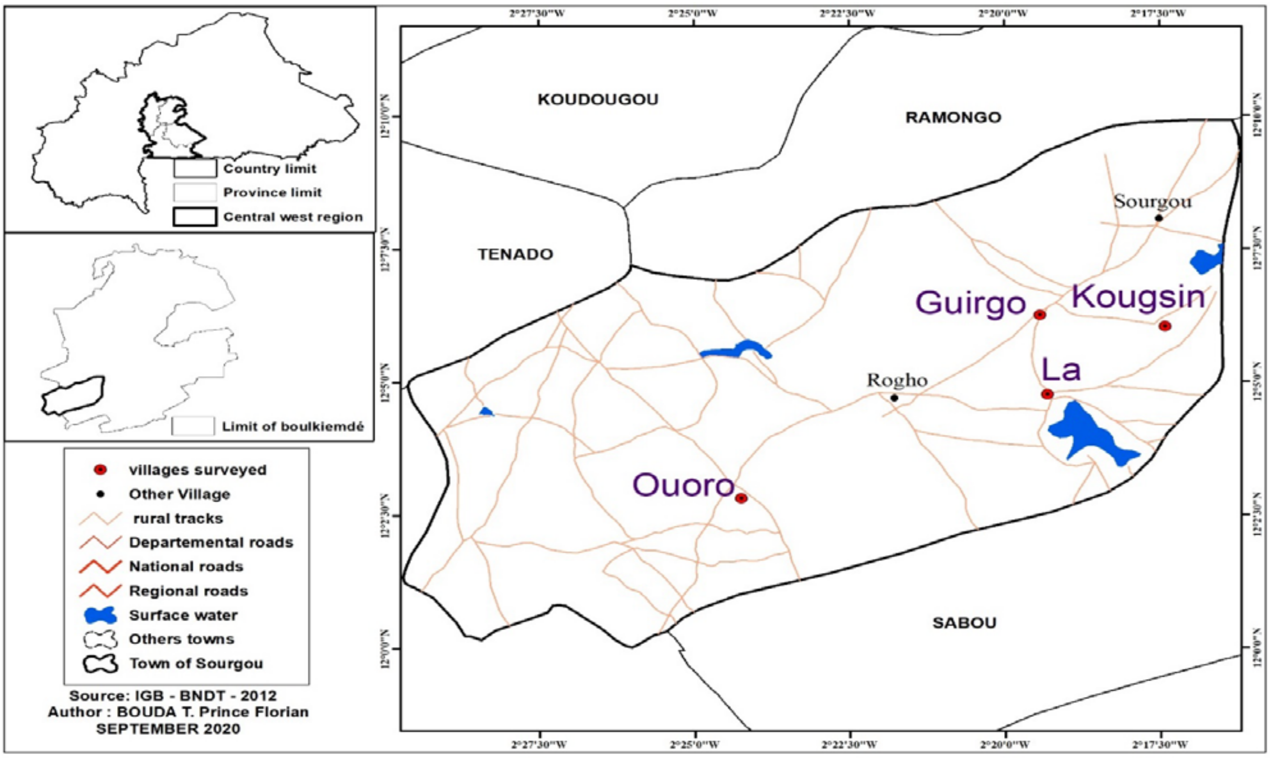

Figure 1. Location of villages under study

To identify the change in rainfall, the use of the Standardized Rainfall Index (SRI) or Standardized Precipitation Index (SPI) was required. Standardized precipitation is calculated by dividing the difference in precipitation from the long-term average by the standard deviation, or the average and standard deviation [12]. Its formula consists as follow:

$$\text{ISP} = \frac{P_{i} - P_{m}}{\sigma}$$

With:
- Pi referring to the rainfall of month or year i;
- Pm is the cumulative rainfall average of the series over the time scale;
- and σ is the standard deviation of the series on the time scale. SPI values associated with the 0 value gives the rainfall trends. SPI enables the identification of the wetness or dryness level in the environment over a given period. It also offers the possibility to determine the trend and irregularity of rainfall. SPI values higher than 0 account for above-normal precipitation (wet periods). Values below 0 show low precipitation (dry periods). All of the PSI values are summarized in Table 1 from McKee and al, (1993), cited by [12,13].

Table 1. SPI value interpretation basing on drought event occurrence

SPI values	Dry season	SPI values	Wet season
0,00<ISP<-0,99	Slightly dry	**0,00<ISP<0,99**	Slightly wet
-1,00<ISP<-1,49	Moderately dry	**1,00<ISP<1,49**	Moderately wet
-1,50<ISP<-1,99	Highly dry	**1,50<ISP<1,99**	Highly wet
ISP<-2,00	Extremely dry	**ISP>2**	Extremely wet

Source: Adapted by McKee et al., (1993).

Surveys covered a sample of 422 households with 29% of them living in Ouoro, 44.72% in La village, and 30.85% in Kougsin. In the Guirgho area, all households (100%) were interviewed. Such data were considered basing on the calculation method developed by Krejcie and Morgan (1970) cited by [14] on different sample choices and studies from researchers on sampling method for communes, including Cochran (1977) cited by [14]. For a sample of 422 producers, the margin of error that will be accepted shall be more or less 0.05% [14].

The choice of localities was made according to the following criteria: the location of water reservoirs used by the population for related activities such as market gardening, cash crops, off-season farming; but also, the experience in agricultural production system.

Cochran's (1977) sample calculation formula consists as follow:

Our gross E sample is calculated by

$$Eb = \frac{(t)^{2} \times (p)(q)}{(d)^{2}}.$$

In the formula, t refers to the acceptable alpha error (0.01 at 5%); (p)(q) is the variance of the sample; (d) is the acceptable margin of error (3% according to Krejcie and Morgan, (1970) cited by [14].

After obtaining the gross sample, Cochran proposes a smoothing of the sample by calculating the sample required for the study as follows:

$$E = \frac{Eb}{\left(1 + \frac{Eb}{P}\right)}$$

With P referring to the population size.

Table 2 shows the number and proportion of households interviewed per village.

Table 2. Households interviewed per village

Villages interviewed	Total of households per village	Total of households interviewed per village	Proportion of interviewed households
Ouoro	488	146	30 %
La	284	127	45 %
Kougsin	188	58	31 %
Guirgho	91	91	100%
Total	**1051**	**422**	**40.15 %**

Source: Field survey, 2020.

Meteorological data collected at the Agence Nationale de la Météorologie (ANAM) originate from the Ouagadougou synoptic station. These data relate to rainfall, temperature and wind speed between 1989 and 2018. ArcMap software was used for mapping and Excel and Word softwares for data entry and processing.

3. Results and Analysis

3.1. Climate Feature Analysis from a Scientific Perspective

3.1.1. Rainfall Changes

Figure 2 analysis shows inter-annual rainfall variability. Wettest years respectively include 2014; 2016; 1999; 2010 and 1991 with a minimum total rainwater record of 900 mm. The rainiest peak is 1994 with 1152.8 mm of rainfall, and the least rainy months is 620 mm recorded in 1990. Overall, rainfall trend varies from one year to another.

Figure 3 shows the evolution of rainfall changes compared to the average quantity from 1989 to 2018. The general analysis of the trend diagram of rainfall changes compared to the average quantity shows a tri-modal trend characterized by years with surplus, average and deficit rainfall. The whole series, through the trend line, shows an increasing decrease in rainfall.

Standardized precipitation index (SPI) shows fourteen years slightly wet and dominating the entire series, seven slightly dry years, four moderately dry years, four moderately wet years, two highly dry years in 1990 and 2013 and exceptionally one extremely wet year recorded in 1994.

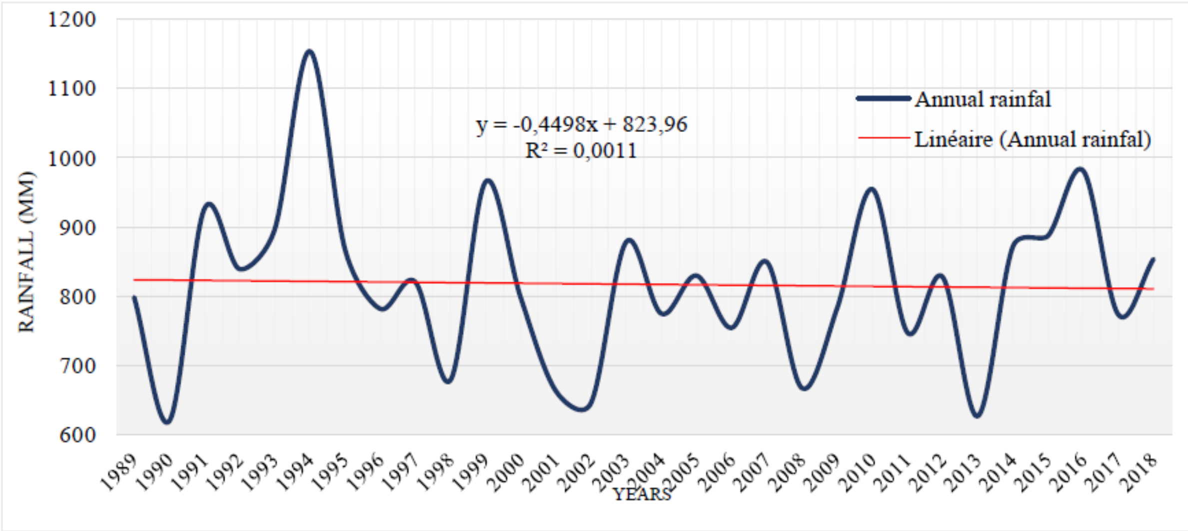

Figure 2. Totals of rainfall changes at Saria station from 1989 to 2018 (Source: National Meteorological Directorate (Burkina Faso), 2020)

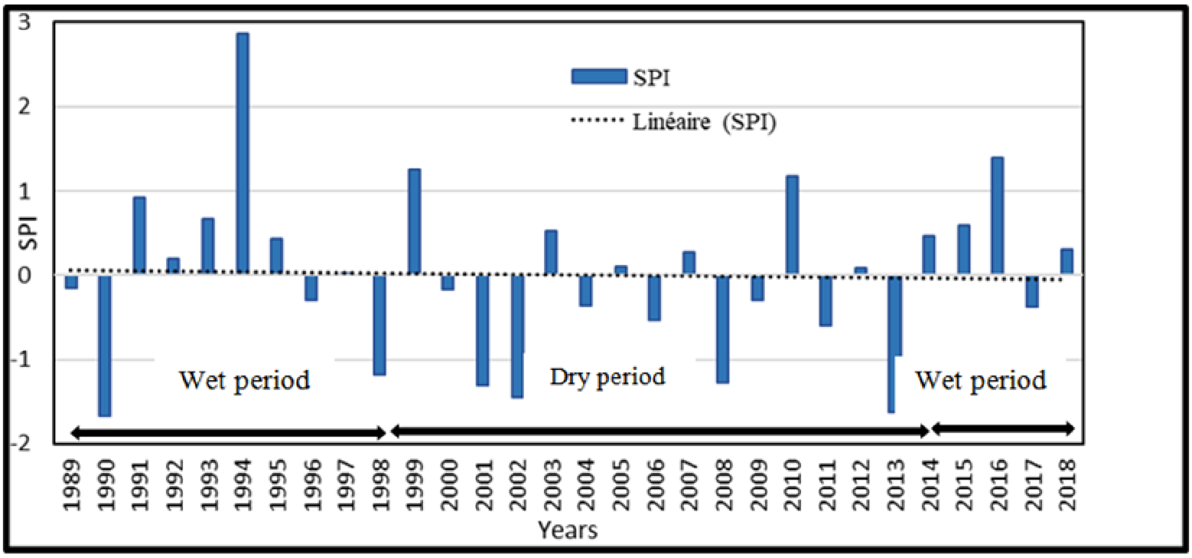

Figure 3. Changes in evolution compared to average rainfall from 1989 to 2018 (Source: National meteorological Directorate (Burkina Faso), 2020)

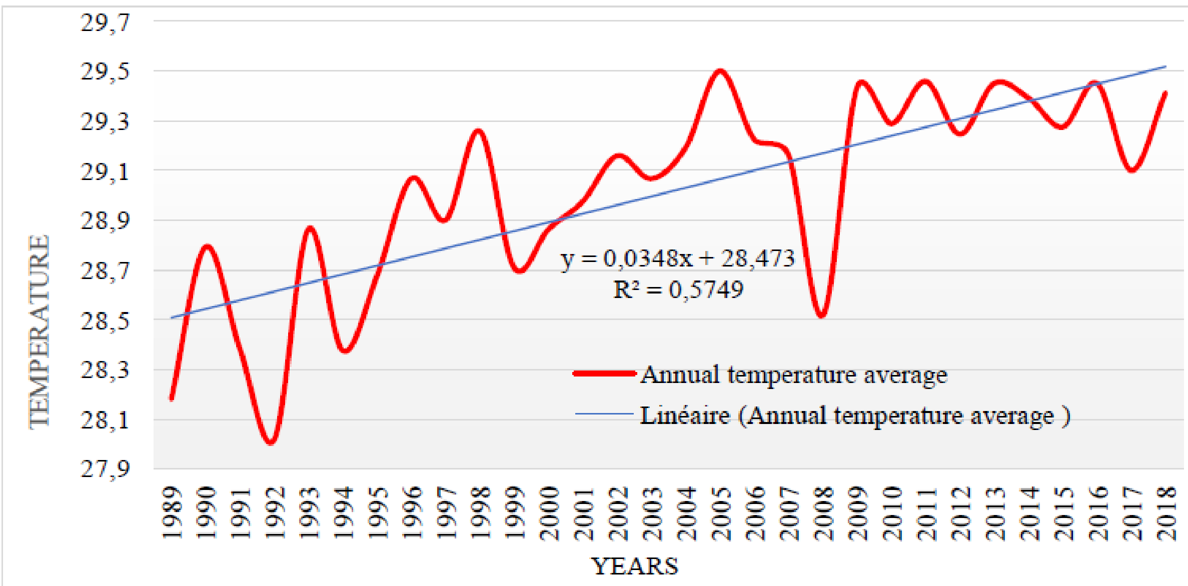

Figure 4. Changes in annual average temperatures from 1989 to 2018 (Source: National Meteorological Directorate (Burkina Faso), 2020)

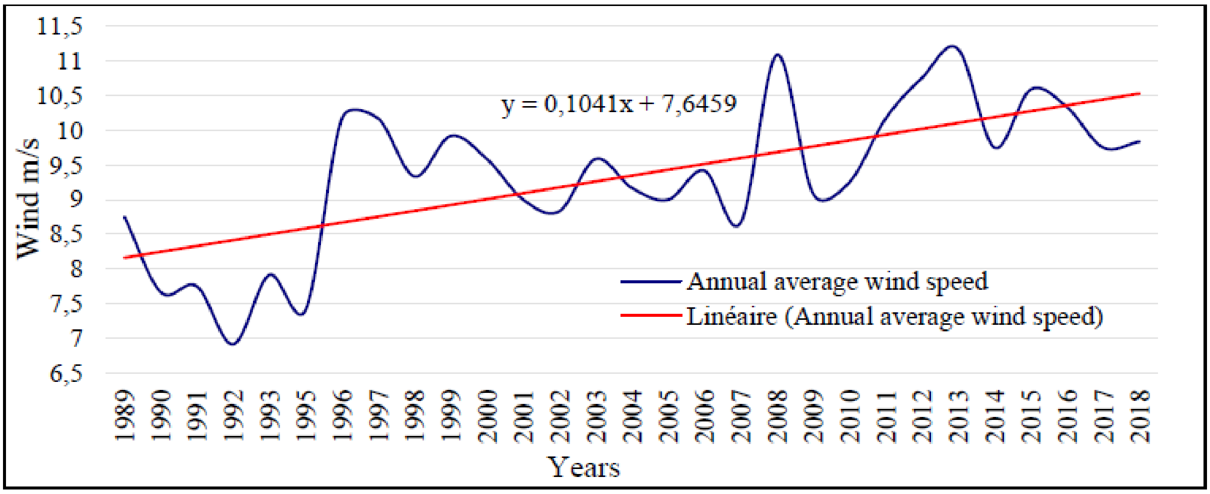

Figure 5. Changes in annual average wind speeds from 1989 to 2018 (Source: National Meteorological Directorate (Burkina Faso), 2020)

3.1.2. Temperature Increase

Analysis of the evolution curve of average temperatures reveals an ascending trend with several oscillating phases (Figure 4). From temperature data recorded per year, it is possible to observe a rising (linear) trend line from the 1990s until 2018, with stable periods from 1992 to 2008. However, extremes in annual average values include 28.02°C in 1992 and 29.46°C in 2011.

3.1.3. Wind speed change

The trend line of annual mean wind speed shows an increase in wind speed from 1989 to 2018 (Figure 5).

3.2. Local Communities' Perceptions of Climate Trends

3.2.1. Rainfall Changes

Local communities involved in the study area perceive climate considering its link with their environments and activities. For farmers, climate is defined considering its relation to common meteorological features such as rain, temperature and wind to a lesser extent. From the whole population considered for the survey, 88.5% stated that the agricultural seasons are getting shorter and shorter (including 99.3% in Ouoro, 76.4% in La, 83.3% in Guirgho and 96.6% in Kougsin). As a result, for the duration of drought pockets, 11.8% respondents respectively stated them to last less than 7 days, 31.2% to be between 7 to 10 days and 57% to exceed 10 days in their localities.

Besides, populations surveyed are very apprehensive about extreme weather conditions. Thus, 69.3% declared having already experienced one drought event, including 67.1% in Ouoro, 70.1% in La, 61.8% in Guirgho, and 84.5% in Kougsin; compared to 30.7% from the whole surveyed population who declared having experienced episodes such as pockets of drought.

All data about perception of seasons in the commune refer to a shift in the different seasons, especially the rainy season, its shortening and an extension of the dry periods. 91.2% of respondents stated that the rainy season is getting drier and drier (98.6% in Ouoro, 81.1% in La, 94.5% in Guirgho, and 89.7% in Kougsin). Only 4.8% said that the season is becoming normal. Reasons for such statements include the occurrence of dry spells at the beginning or middle of the season or at a reduced interval from the normal harvest period. The majority of respondents, namely 87.6%, stated that the rainy season start late, with false starts at times.

3.2.2. Temperature Increase

Farmers' perceptions is not only related to rainfall, but also to temperature, which also affects agricultural production in the Sourgou commune. As a result, 87.6% of respondents said that temperature has increased. With regard to cold periods, 70.2% of respondents highlighted an increase in cold periods. 43.3% of respondents noticed an increase in temperature during the rainy season, while 56.7% considered it to be normal.

3.2.3. Changes in Wind Speed

Local communities involved in the study noted a change in wind speed. This evolution is observed during the monsoon and the harmattan. From a general perspective, 96.4% of farmers surveyed stated that the monsoon and harmattan winds have been more violent over the past thirty years. From their observation, wind is getting more and more violent during the monsoon (83.4%). They also added (94.1% of respondents) that winds are more devastating during the rainy season because of their direct impact on agricultural crops. However, 3.8% of farmers assumed that monsoon winds were stable. 41.2% interviewed farmers mentioned an increase in wind strength during the dry season (harmattan).

3.3. Local Communities' Coping Strategies Associated with Resilience Measures

In the four villages surveyed, farmers adopt strategies based on their perceptions of the climate. These measures could relieve them, and mitigate as much as possible the effects of climate variability on their agricultural production. These include soil and water conservation techniques (SWC) such as the zaï technique and stone cordons, the use of improved seeds, mulching, and irrigation. The Zaï technique is much appreciated and used by 24.5% of the farmers, the reason being that it allows the concentration of rainwater and nutrients inside the pits. The construction of stone barriers is a fairly common practice in the study sites. Many farmers (60.4% among those surveyed) use this technique as it favors high water retention capacity in the fields and provides good moist conditions for plant growth.

The half-moon technique is used by 3.3% of the farmers surveyed. It's a highly appreciated technique by the farmers but less used. Failure to adopt it is due to the fact that it requires much workforce, heavy equipment-related costs and a large amount of time for its implementation.

The use of improved seeds is still low in the commune. Only 8.3% of farmers in the study sites use improved varieties, which grow faster compared to traditional seeds.

Mulching is a technique used in the study sites. This technique is much easier to use because it requires little effort from producer. In the commune of Sourgou, 27.3% of producers use it.

In addition to these mechanical and biological strategies, some farmers use irrigation as a strategy. Farmers use drip irrigation, which consists of bringing pressured water through a pipe system. Water is then distributed in drops to its crop plots. For irrigation, farmers use motor pumps, but also traditional methods with wells as surface irrigation. Irrigation is practiced in the dry season and also in the rainy season. So, 1.7% of the producers interviewed use this technique. This low use is due to the lack of means from producers in villages surveyed and the existence of water bodies.

4. Discussion

From the various climate features studied in Burkina Faso, rainfall, temperature and wind are the most frequently mentioned by farmers in the study areas. This situation is due to the fact that these three climate variables have a more direct impact on agricultural production and determine how good or bad agricultural season can be. According to [15], rainfall, wind and temperature are the most memorable and visible climate features by local people. For [7], populations define climate basing on its common meteorological factors such as rain, temperature and wind to a lesser extent. According to [9], decreasing rainfall is being observed by farmers, namely 46% of the rural population in the Sudano-Sahelian area. According to [16], almost all (99%) of farmers interviewed in the Yakouta watershed noticed a deterioration of the climate in general. For 66% of those interviewed in Yakouta, precipitation has decreased in intensity and quantity. A similar study in the localities of Goé and Voaga in the Plateau central region of Burkina Faso revealed that 79% of sampled farmers reported a decrease in rainfall [13].

The farmers' observing of the decrease in rainfall and the number of rainy days in the study villages resonate with the results of studies in Burkina Faso. According to [17], farmers in the northern centre part of Burkina Faso notice a decrease in rainfall, a significant decrease in rainfall per year in their environment. [18] made the same observation with Oula farmers in the northern region of Burkina Faso. Studies in other parts of Africa have shown similar results [19,20], in southern and central Benin. According to these authors, 97% of the people surveyed reported a decrease in rainy days, and 97% stated that pockets of drought were increasingly common after heavy rains. Indeed, according to [21], severe droughts have gradually increased in number in the sub-region and Burkina Faso over the past few years. Temperature increase is also observed by other farmers in different parts of Burkina Faso and Africa. According to [15], 80% of farmers surveyed in Tougou and Donsin noticed an increase in overall temperatures. Such observations are consistent with studies conducted by [22], showing that 50.16% of respondents observed a rise in temperatures supported by meteorological data. These results are similar to those obtained by [23] in the Sourou valley in Burkina Faso.

The increase in temperature is also highlighted by 83% of farmers in the study of Ilboudo et al. For most stakeholders with peasant views, it is observed that temperature increase is also consistent with several other scientific data [16,17,18,24]. The impact of rising temperatures on agricultural production is a major concern for farmers in the study sites. Indeed, increased temperatures can result in the rapid multiplication of insects with significant damage to crops [18].

Producers' perceptions in the villages surveyed resonate with those from the villages of Tougou and Donsin in the study of Bambara and al. According to these authors, 60% of the people from these villages observe an increase in wind patterns manifested by strong vortices during both seasons and dust mists. These results match those obtained by [25] in Oula in the northern region of Burkina Faso and in the localities of Goué and Voaga in the Plateau central region where violent and destructive winds is highlighted by 84% of the farmers interviewed [13]. They claim that increased winds lead to soil erosion in the dry season and to the destruction of houses, uprooting of trees, defoliation and lodging of crops in the rainy season. Although wind speed changes are observed by farmers in several places in Burkina Faso, other studies invalidate these observations. Indeed, the results of [26] study over the 1991-2010 period and [27] time series (1969-2008) indicate a decrease in wind speed.

The importance of having adaptation strategies as resilience measures is echoed by several authors. For [9], strategies developed by farmers are meant to adapt on the one hand and to reduce their vulnerability to the impacts of the rainfall changes on the other. Authors such as [18,22,26,28] have made similar findings in their studies. According to [25], farmer's acceptance and conviction of the existence of climate change in agriculture favors better risk and change management capacities.

Zaï is common in different regions of Burkina Faso. [18]; [17] also mentioned the use of zaï on degraded land in their study areas. A similar study by [11], shows that 49.1% of farm households sampled in the northern region of Burkina Faso have adopted the zaï technique over the past four decades (1974 to 2013). According to [7], the improved form of zaï enables substantial yield improvements. However, [29] notes that simply improving water availability by breaking the surface crust of soils is not enough to lead to increased agricultural production. And [7], adds that the use of zaï is not appropriate on all types of soil.

According to [7] Dipama, stone barriers are isohypsis structures designed to reduce the effects of soil skinning by rainwater runoff. According to [18], 85% of farmers have adopted the construction of stone barriers as an anti-erosion measure and to recover degraded land. Stone barriers were adopted by 68.7% of farming households between 1974 and 2013 [11].

Short-cycle varieties adapt to the shortening of the rainy season. Such varieties are more widely adopted in the Sudano-Sahelian region due to the greater vulnerability of this region to some climate features [9]. New varieties are used by 47.27% farmers in the Sudano-Sahelian area [9]. According to [30], in many Sub-Saharan African countries, including Burkina Faso, seeds are one of the main factors to consider for agricultural yields. Improved seeds aim to provide producers with new varieties able to resist new climate changes in terms of adaptation. [16] state that improved or early varieties are part of the strategies adopted by farmers, especially in the Yakouta watershed. For farmers in the northern centre region of Burkina Faso, improved seeds allowed a significant time reduction in the production cycle and a better resilience of plants to the climate variability [27].

Studies by [27] show that mulching is also used in the eastern centre region of Burkina Faso where it is used both in rainfed and irrigated fields to preserve soil moisture and reduce evaporation due to rising temperatures during the dry season. This technique has also been mentioned in other studies, including the one conducted by [31] revealing that 12% of agricultural producers surveyed in Gouré, Niger use mulching in their farms. According to [32], zaï, cordons of grass, stone cordons, mulching and half-moons are effective in combating erosion and the low fertility of cultivated land. These techniques are used in relatively dry areas where erosion has spread over cultivated land. Moreover, these techniques have impacts on the soil and its regeneration. According to some authors, water and soil conservation techniques, ensure water and soil conservation, contribute towards worsening the effects of main species in terms of floristic richness [29-33].

Depending on the availability of water, irrigated farming is practiced in the villages considered for the study. According to populations, this form of adaptation allows them to make a better living as profits from this activity enable them to buy agricultural equipment and care for their households. According to [9], irrigation is used by only 1.45% of the people surveyed in the Sudano-Sahelian region. Difficult access to water is mainly the reason why adoption rate is low. The use of irrigated crops by farmers as control strategies is also mentioned by [31]. Studies conducted by [17] revealed that farmers, given the inability to access water, dig trenches to minor beds of dams for pumping.

5. Conclusion

Results from the study suggest a good perception of climate-related effects on farmers' environment, though their perception of climate features remain different. The impact of climate variability on the study sites has scientifically-measurable and quantifiable consequences. Farmers' observations sometimes resonate with the scientific data. This apprehension is all the more visible when scientific data are highly consistent with local populations' observations. Climate change allows farmers to adopt strategies aiming at resilience its effects. Farmers' adaptation strategies range from old to new strategies. Strategies' implementation requires financial and material resources which are difficult to find by famers. For some aspects of climate change, some farmers are not convinced that their effects are due to a change in the climate. Yet a sheer understanding of such changes could lead them to develop a better control strategy. The various mechanical and biological techniques used in our study area aim to increase the yields of those who use them and to resilience as much as possible the impact of climate-related effects. However, challenges faced by farmers seem to be similar and local communities feel the need to adopt strategies to face the impacts of climate variability. Essentially, farmers awareness of climate-induced effects provides an advantage in developing adapting strategies with the substantial support from government, NGOs, and other partners.

This study revealed that the peasant adaptation strategies put in place are increasingly popularized in the study villages in view of their positive impacts on their agricultural activities. However, the study did not address access to climate information which was an important concern raised by several respondents in the study area. Indeed, climate information allows farmers to better organize their farming activities according to the agricultural seasons. A more in-depth study would make it possible to make objective proposals in this direction.

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