

Climate Change Perceptions and Resilience Strategies of Groundnut (*Arachis hypogaea* L.) Growers in the Commune of Kelle Gueye (Louga, Senegal)

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Abstract

The municipality of Kelle Gueye is severely affected by climate change-induced disturbances, which manifest themselves in an increase in average temperature, irregular rainfall patterns, and an increased frequency of extreme weather events, significantly impacting agricultural activity. This study aims to assess the influence of climate change on peanut production. To this end, 48 producers in five villages in the municipality were surveyed, and secondary agronomic and climatic data were collected from the SDDR and ANACIM, respectively. The villages were selected based on their accessibility and the availability of secondary agronomic data. The correlation analysis reveals that temperature plays a decisive role in production, showing a strong positive correlation with yield ($r = 0.70$). Qualitative variables related to farmers' perceptions of climate change and their resilience strategies did not show statistically significant results at the 5% threshold with respective p-values ($P \leq 0.05$). According to 98% of surveys, climate variations have a negative impact on peanut production in the municipality of Kelle Gueye. These results highlight the need for agronomists to select varieties that are adapted to these changes in order to strengthen their resilience. It would be relevant to conduct further research on natural mechanisms of resilience to climate change, particularly by exploring agroecological practices or adapted local varieties.

Keywords

Climate Change, Agriculture, Groundnut, Senegal, Louga, Vulnerability, Resilience

1. Introduction

In the Sahel, climate change is accompanied by a multitude of consequences, most of which are negative for the physical environment and agriculture [1]. In Senegal, agriculture remains the main source of subsistence and food for the population. It employs nearly 70% of the working population and accounts for 18% of GDP [2]. Although Senegalese agriculture is tending to modernise, it is still largely dependent on climatic factors such as rainfall. Groundnut production is expected to be 1501 tonnes in 2022 and 498 tonnes in 2023, down 11% on the previous crop year [3]. Climate change poses enormous challenges to agricultural production and sustainable livelihoods in Senegal. On the Global Climate Risk Index 2019, the country is among the highest climate risk countries in the world, with a ranking of 70/189 [4]. Agriculture is characterised by rainfed crops, low farm incomes and means of production that are severely limited by the poor accessibility of the market for products, agricultural inputs and financial instruments for farmers. In addition, the rainy season is short (3 - 4 months per year); these characteristics make agriculture in Senegal very vulnerable to climatic hazards, and particularly to the variability of water resources. The characterisation of climate change and the adaptation of agriculture to future changes are major issues for this country [5] [6]. Crises and disasters caused by climate change have a negative impact on natural resources (NR) and on farming activities. Drought and rising temperatures are direct consequences of climate change [7]. The north of the Senegalese groundnut basin is particularly vulnerable to climate change, which is reflected in rising temperatures and irregular rainfall. These changes have a direct impact on farming activities and food security. As a result, harvests are compromised and populations are looking for ways to adapt to the situation [6]. Although the impacts of climate change are increasingly being studied in Senegal, specific studies would provide a better understanding of local specificities and adaptation strategies [8]. This study therefore asks the following questions: 1) Is there a link between climate variations and groundnut production? 2) How do farmers perceive changes in climatic parameters? and 3) What resilience strategies have farmers implemented to cope with the impacts of changes in climatic parameters? The aim of this study is to investigate groundnut growers' perceptions of climate change and their resilience strategies. To meet this objective, the following research hypotheses were put forward: 1) variations in temperature and rainfall have a significant impact on groundnut farmers' activities, resulting in changes in yields and cultivated areas; 2) stakeholders feel that changes in rainfall patterns and an increase in temperature are disrupting the groundnut crop itinerary; and 3) farmers have developed practices to cope with disruptions to farming activities caused by changes in temperature and rainfall.

2. Materials And Methods

Study Environment

The study area is the commune of Kelle Gueye in the department of Louga, Louga

region. Geographically, the commune is bordered by the communes of Nguidile to the east, Badegne Ouolof to the west, Nguene Sarr to the north, Ngourane Ouolof to the south and Mbediene to the south-east (**Figure 1**). The commune comprises forty (40) villages, including the five (5) villages that make up the survey sites: Kelle Gueye, Kelle Ndiaye, Ndoukoumane, Kelle Loro and Ngana Kelle. It has a flat topography with some dune formations on the eastern periphery. It is characterised by its agricultural and pastoral uses, but also by the degradation of its environment. The commune's sandy (dior), clayey (deek) and sandy-clay (deck-dior) soils limit the possibilities for diversification of farming systems [9] [10]. The average annual temperature in the region is marked by a longitudinal gradient from the coast to the interior, rising from 26.5°C [11] and rainfall varies between 300 and 400 mm per year [6]. There are two distinct seasons in this area: the dry season (mid-October to mid-July), which is mainly characterised by a lack of rainfall, and the rainy season or wintering period, which is characterised by the arrival of the African monsoon from mid-July to mid-October [12]. The vegetation is characterised by a typically Sahelian shrub steppe.

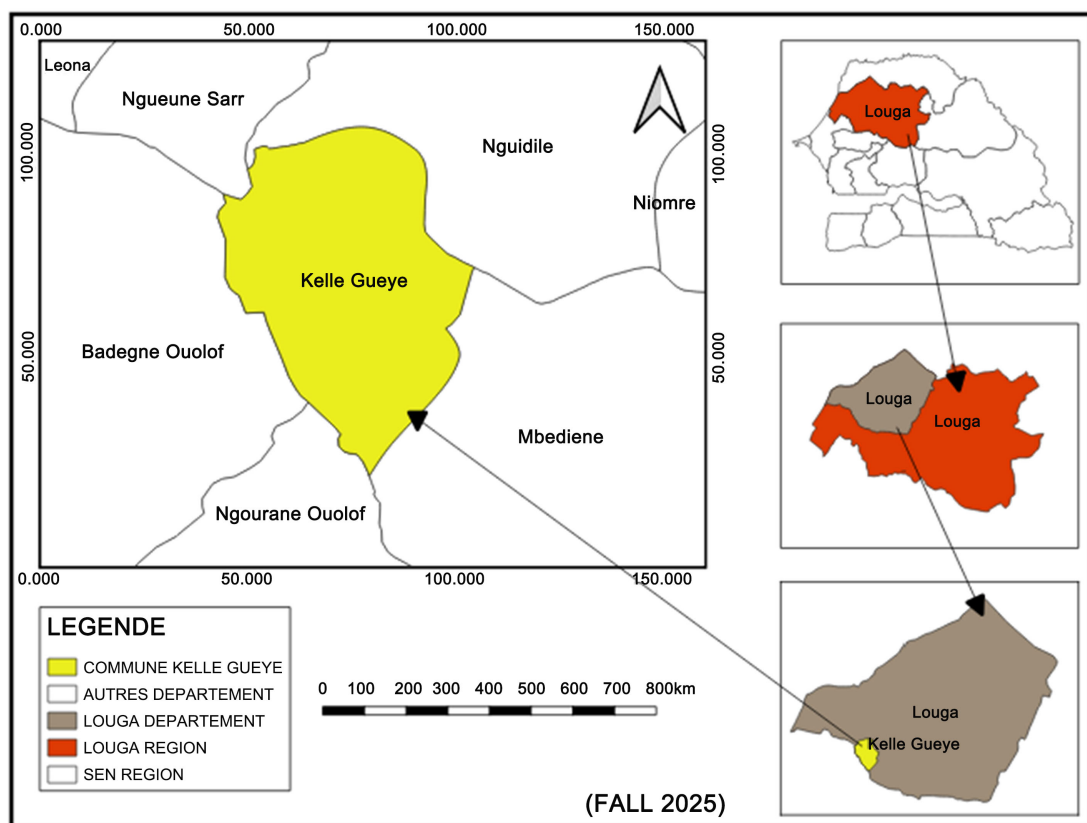


Figure 1. Location of the commune of Kelle Gueye.

3. Methods

3.1. Surveys

The choice of villages for the surveys was guided by several interdependent crite-

ria: accessibility and production capacity (according to information from the Louga DRDR), the geographical concentration of localities to optimise logistics, the availability of potentially complementary secondary data, and the presence of experienced producers likely to offer a historical perspective on the changes. The farmers were categorised according to the size of their farms (Table 1). Two-stage sampling (village and producer) was used to select the groundnut producers to be surveyed in each village.

The sample of stakeholders to be surveyed was random. To determine the sample size, formula 1 of [13] was used:

$$nf = \frac{n}{1 + \frac{n}{N}} \quad (1),$$

where nf is the sample size; n is the degree of representativeness of the sample; n is given by the formul $n = \frac{1}{d^2}$, where: d is the tolerated margin of error, which is 10% for our study.

As the sample size was 48 producers (Table 2), the number of producers to be surveyed per village was determined as a function of the size of these five (5) villages, using the following formula (2):

$$X = \frac{nf * Y}{N} \quad (2),$$

where X is the sample size per village and Y is the number of farmers per village.

Producers were selected at random. The database resulting from the survey of the five villages (5) in the commune of Kelle Gueye was used. A questionnaire was drawn up and administered to the various groundnut producers.

Table 1. Categorisation of producers.

Producer category	Farm size (ha)
1 st category]0 to 5]
2 nd category]5 to 10]
3 rd category]10 to 15]
4 th category	>15

Table 2. Stakeholders surveyed by village and producer category.

Villages	Producers	Surveyed	Category 1	Category 2	Category 3	Category 4
Kelle Ndiaye	22	11	3	6	0	2
Ndoukoumane	9	5	1	2	1	1
Kelle Gueye	23	12	9	2	1	0
Kelle Loro	12	6	3	2	1	0
Ngana Kelle	27	14	2	8	2	2
Total	93	48	18	20	5	5

3.2. Secondary Data Collection

Climatic data from 1993 to 2023 and agronomic data from 2011 to 2023 were collected from National Agency for Civil Aviation and Meteorology (ANACIM) and Régional Directorate for Rural Development (DRDR) in Louga, respectively.

3.3. Data Processing and Analysis

Using R 4.3.1 software, the Pearson correlation matrix was applied to establish relationships between climatic and agronomic data. Categorical variables (perceptions regarding the category of producers) were subjected to a Chi² test of independence. Results are considered significant if $P \leq 0.05$ and highly significant when $P < 0.01$.

4. Results

4.1. Socio-Demographic Characterisation of Producers

The profile of the producers surveyed in the commune reveals a predominantly male population (75%), educated in Arabic (90%), mainly of Wolof ethnicity (94%), often members of agricultural groups (71%) and generally married (81%). The age structure indicates an ageing farming population (73%). The vast majority of growers have a good knowledge of the varieties grown (90%) (**Table 3**).

Table 3. General characteristics of farmers surveyed.

Variables	Qualitative characteristics	Percentage (%)
Sex	Male	75
	Female	25
Type of education	Arabic	90
	French	10
Ethnic group	Wolof	94
	Peulh	6
Belonging to a group	Yes	71
	No	29
Marital status	Married	81
	Single	13
	Widowed	4
	Divorced	2
Age	Over 60	33
	50 - 60 years old	40
	40 - 50 years old	13
	30 - 40 years old	10
	20 - 30 years old	4
Knowledge of the variety	Yes	90
	No	10

4.2. Relationship between Climatic Variations and Groundnut Production

Table 4 shows the relationship between climatic parameters (temperature, rainfall) and production (yield, production, area). Rainfall shows a moderate positive correlation with total production (0.35) and yield per hectare (0.45). The correlation with area is positive but weaker (0.27). Area has a weak positive correlation with temperature (0.27). Temperature is strongly correlated with yield (0.70). None of the correlations with rainfall were statistically significant at the 0.05 threshold (p-values > 0.05). The correlation between yield and temperature was statistically significant (p-value = 0.010).

Table 4. Correlation matrix for climatic and agronomic parameters at Kelle Gueye from 2011 to 2023.

	Rainfall	Temperature	Yield	Production	Area
Rainfall	1	0.53	0.45	0.35	0.27
Temperature	0.53	1	0.70**	0.37	0.27
Yield	0.45	0.70	1	0.39	0.11
Production	0.35	0.37	0.39	1	0.37
Area	0.27	0.27	0.11	0.37	1

** : very significant.

4.3. Growers' Perceptions of Changes in Rainfall and Temperature

Figure 2 shows farmers' perceptions of changes in rainfall. The majority of respondents (79%) said that the amount of rain had decreased in recent years. For some (15%), there has been a small increase in rainfall, while for others (2%), it is difficult to quantify the increase, as it was God's will.

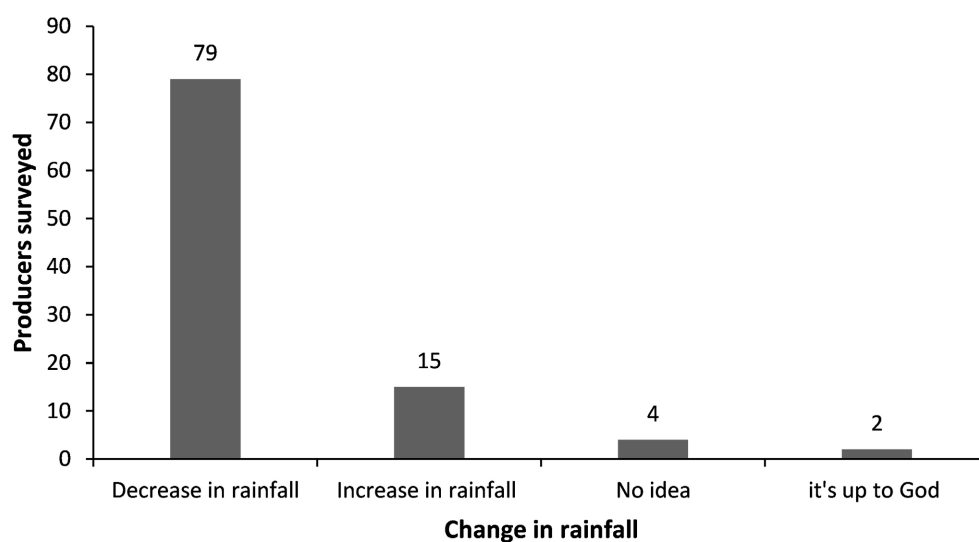


Figure 2. Proportion of respondents according to their perceptions of the amount of rainfall.

Figure 3 illustrates the perceptions of the farmers surveyed regarding the distribution of rain during the season. The poor distribution of rain is the dominant perception, reported by a large majority of growers (65%). A not insignificant number of growers observed insufficient rainfall during crop flowering (13%). Some growers (10%) noted a greater amount of rain during the sowing periods and 6% of growers perceived a greater amount of rain in the middle of the season. Only 2% of growers felt that the distribution of rain over the season was normal.

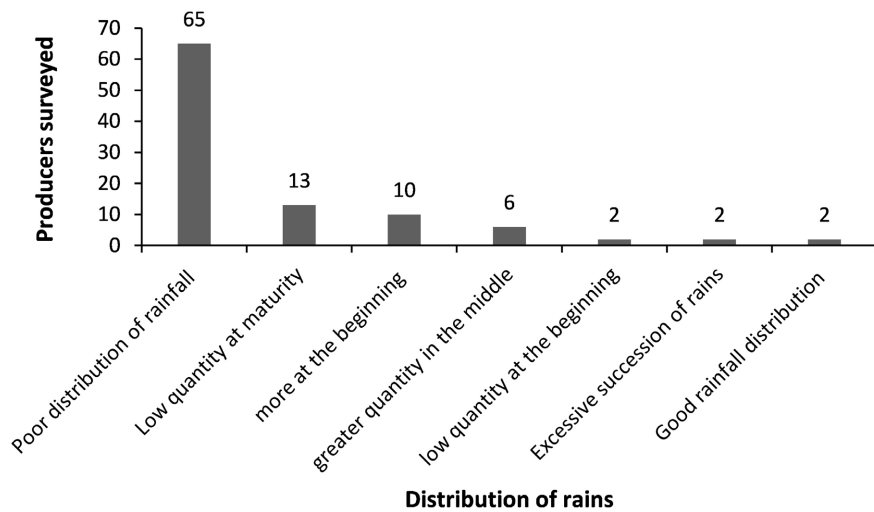


Figure 3. Proportion of respondents according to their perceptions of rainfall distribution.

Figure 4 highlights farmers’ perceptions of whether the first heavy rains came late or early. Of those surveyed, 71% said that there had been a change in the arrival of the heavy rains, with a delay. Some of them (13%) noticed an earlier arrival. Despite this, 10% of growers found that the first heavy rains were irregular, arriving sometimes early and sometimes late. Only 2% of growers perceived a normal arrival of heavy rains, 2% found it difficult to recognize, and 2% attributed it to God's business.

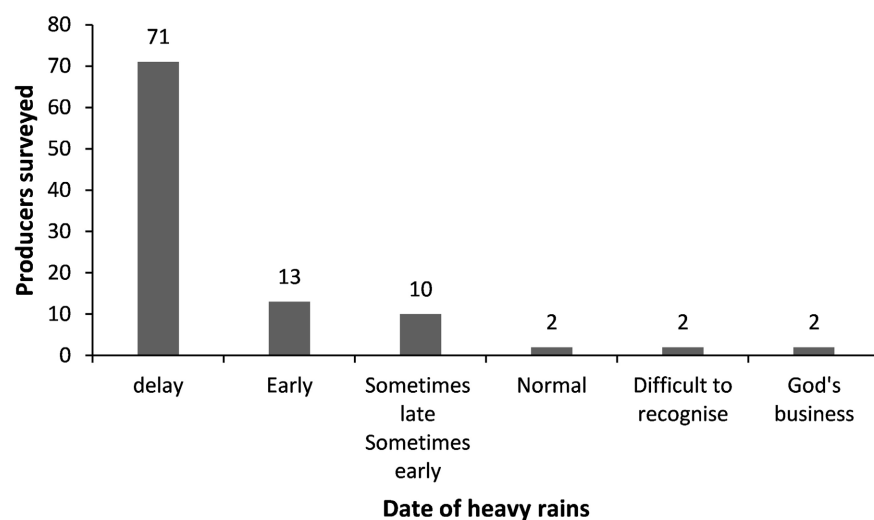


Figure 4. Proportion of respondents according to their perceptions of the date of the first heavy rains.

Figure 5 shows the respondents' answers regarding changes in temperature. The results show that 37% perceive a warming, 42% a cooling and 13% a variability. Only 4% said that the temperature had not changed.

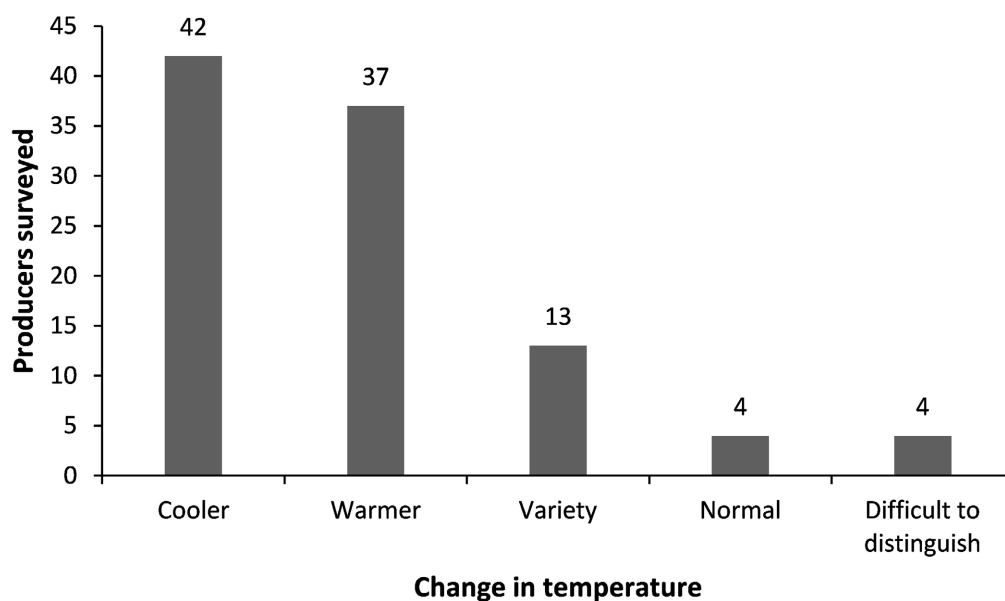


Figure 5. Proportion of respondents according to their perceptions of temperature change.

The results of the Chi² test on respondents' perceptions of climate change are shown in **Table 5**. Examination of the results shows that, at the 5% threshold, temperature and rainfall are not significant.

Table 5. Results of the Chi-square test on farmers' perception of climate change at the 5% threshold.

Variables	Perceptions	χ^2	P-value
Rainfall	Decrease in rainfall	10.936	0.2054
	Late rainfall	3.4	0.9068
Temperature	Poor distribution of rainfall	8.783	0.3609
	Increase in heat	4.718	0.7872

4.4. Farmers' Resilience Strategies in the Face of Climate Change

79% of respondents stated that they had not undertaken any strategy relating to the groundnut varieties grown. Only 21% of respondents are using new groundnut varieties that are earlier than those they used previously (**Figure 6**).

The results show that 56% of respondents had reduced the size of their farms and 44% said they had kept the same area (**Figure 7**).

The results show that 73% of farmers said they had used cowpeas as an alternative crop to groundnuts. The other 27% said that groundnuts were still the only crop grown despite the changes in climate (**Figure 8**).

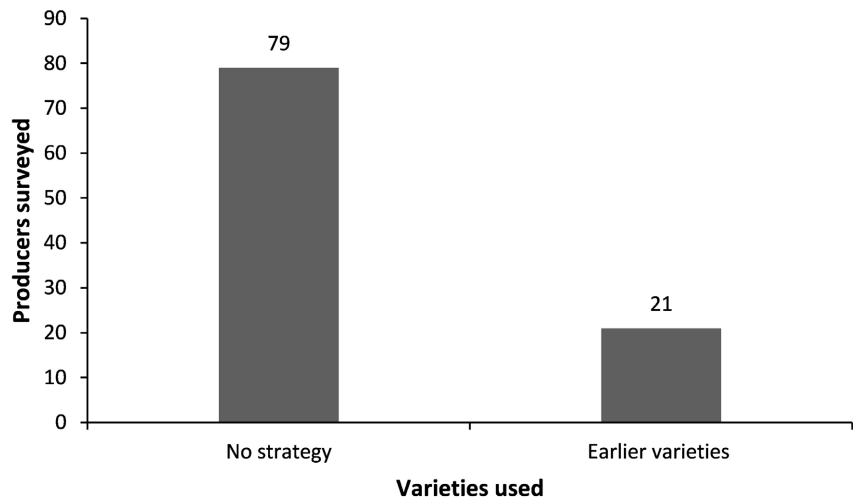


Figure 6. Proportion of respondents according to their groundnut variety strategies.

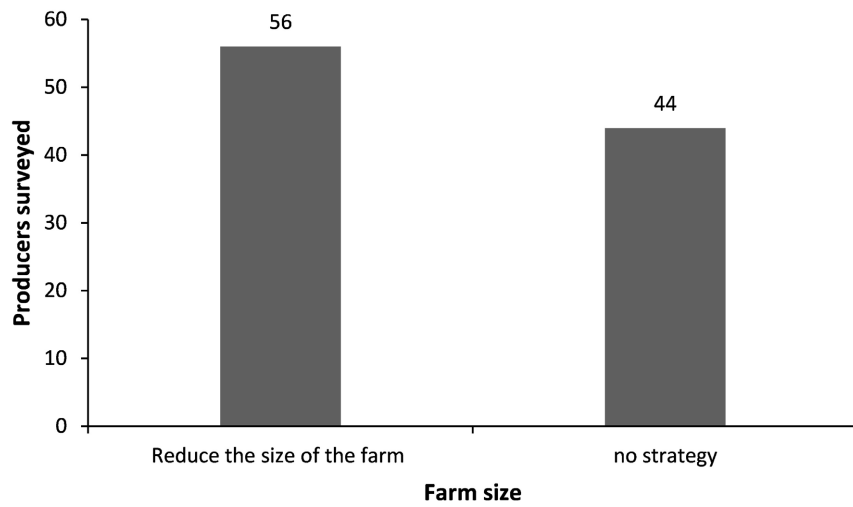


Figure 7. Proportion of respondents according to their farm size strategies.

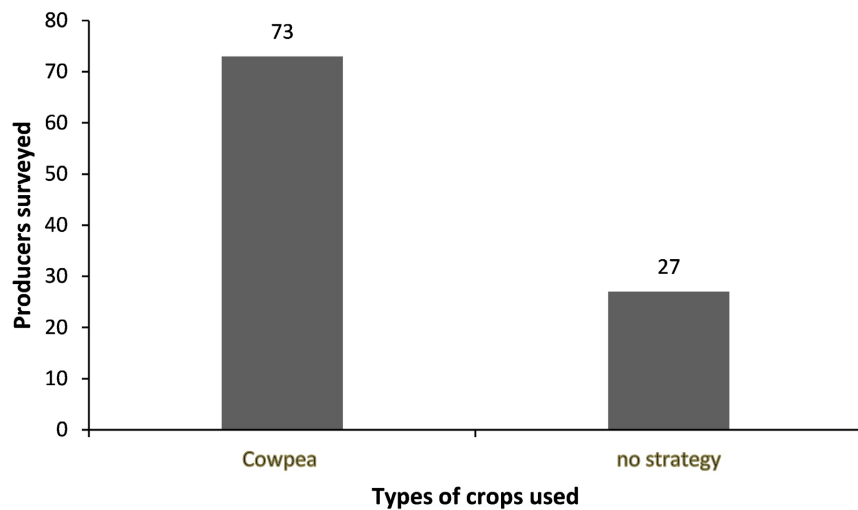


Figure 8. Proportion of respondents according to their crop strategies.

5. Discussion

5.1. Relationship between Climatic Variations and Groundnut Production

The results of the analysis show that the temperature factor has a strong influence on agricultural production (p-value = 0.010). This indicates that rising temperatures tend to promote higher yields. [14] have shown that the particularity of temperature is that its variability leads to changes in other climatic parameters such as rainfall, humidity and the entire atmospheric system. This correlation between temperature increase and production is often not positive. However, these results could be linked to sustainable agricultural practices and adaptation strategies. Similarly, peanuts are considered a short-day plant, and photoperiod can influence growth, development and production. Rainfall showed no statistically significant effect on either production (p-value = 0.355) or yield (p-value = 0.445). This shows that rainfall does not appear to be a determining factor in groundnut production and yield in the Kelle Gueye context. Irregular rainfall and recurrent droughts disrupt sowing periods and adversely affect crop yields [15]. One of the main impacts of climatic variability observed in lowland production in the rural commune of Doumanaba in Mali is the drop in yields [16]. These findings corroborate those of [17], who argue that rainfall variability is a problem for farmers. In Benin, the threats to food security are due to the negative impacts of climatic hazards on agricultural production [18]. An old farmer we met in one of the villages, told us: "Farmers' yields do not depend on rainfall, whether it is large or small, but rather on God's will. In fact, there can be years when the rains are abundant and the harvest is disappointing. However, we can have very good harvests despite low rainfall". These wise remarks are a further reminder to the scientists of the need to delve deeper into local knowledge of the determinants of yield.

5.2. Farmers' Perceptions of Changes in Rainfall

The growers surveyed say that there is a disturbance in temperature and rainfall. These two parameters are easier to perceive because of their impact on human life. The results of the study show that 79%, 65% and 71% of respondents respectively noted a drop in the amount of rain, a poor distribution of rain during the season and a remarkable delay in the first rains. According to the work of [19], most of the women farmers surveyed (99%) said that the seasons were becoming less rainy and shorter, with increasingly long periods of drought. Climate change is also reflected in lower rainfall volumes, recurring dry spells and a shorter rainy season [6]. In Burkina Faso, [20] have shown that the irregularity of rainfall, the reduction in the number of rainy days and the drop in the amount of rain are undeniable indicators of climate change. The same trend was observed in northern Benin, where 98% of local people perceived a delay in the start of the rainy season, pockets of drought during the rainy season and poor spatial distribution of rain [21] [22], in the West African region, showed a break in the rainfall series around the 1970s. [17] have stated in their studies that farmers have noticed an increase in

the frequency and intensity of rainfall over the last decade, leading to the destruction of fields. In the Centre-North region of Burkina Faso, [23] observed an increase in the frequency of extreme rainfall since the late 1980s, and in the 1990s and 2000s.

5.3. Farmers' Perceptions of Changes in Temperature

All the growers confirmed periods of drought during the rainy season, and 37% of those surveyed reported increasingly hot weather. This can be explained by the fact that the commune of Kelle Gueye is not spared by the changes in climatic parameters. The results are consistent with those of [24], who showed an overall increase in minimum temperatures, ranging from 0.58°C in Dakar to around 1.88°C in Ziguinchor, where the rise in minimum temperatures was greater than in Tambacounda (around 1.06°C). Studies by [25] show a late start to the rainy season. [26] also reported an increase in temperatures and drought during the rainy seasons in recent years in the Ségou region. In the same vein, [27] stated that growers in Benguéné in the Ségou region and those in Koumbia and Yilou in Burkina Faso perceive an increase in temperatures and a poor distribution of rainfall. In Algeria, a number of studies on climatic variations project a rise in temperatures by 2050, *i.e.* an increase of 2°C to 3°C [28]. The account of an interviewee aged over 60 in the village of Kelle Ngana is explicit: "The rains used to be much heavier and more regular than they are now; it used to rain morning and evening, but these days everything has changed. The first rains often come late, but in recent years there has been a bit of an early arrival, which is not unanimous, because some people get a lot of rain in their fields, while others don't. I used to be able to distinguish between periods of high rainfall and periods of low rainfall. I used to be able to distinguish between hot and cool periods, but it's been difficult to do that in recent years. Sometimes it's hot, sometimes it's cold". The results are similar to those of [14] in Bukavu, where residents reported feeling intense heat. In countries such as Burkina Faso, Chad, Niger and Kenya, the main agro-climatic risks for farming households are rising temperatures and intense drought [25]-[29]. Although the farmers interviewed revealed that they were feeling rising temperatures, some studies have shown that nowadays the rains have become more intense [30] [31].

5.4. Farmers' Resilience Strategies to Climate Change

5.4.1. Resilience Strategies Linked to Farm Size

To ensure resilience in the face of climatic disturbances, particularly rainfall, 56% of those surveyed decided to reduce the size of their farms. This practice would enable farmers to minimise the risk of losses and adapt to late rains. It requires resources and sufficient land. Work by [18] shows that the strategies adopted by large-scale producers require either financial resources or the availability of a large area. These results are not in line with those of [32], who found that because of falling production, farmers prefer to use chemical products, which remain the only alternative, despite the harmful effects on people's health. In Burkina Faso,

Chad and Niger, farmers are adopting innovative adaptation practices such as expanding irrigation systems, adjusting crop sowing periods according to local climate forecasts, plant selection and the introduction of crops that are more tolerant of climatic stresses, combined with agroforestry [25].

5.4.2. Resilience Strategies Linked to New Varieties

Only 21% of respondents use early varieties as an alternative. This low percentage can be explained by the lack of information about these new varieties, the high cost of certified seed and their attachment to their ancestral practices. Women farmers (87%) have gradually abandoned local maize varieties, which are long-cycle varieties, in favour of new short-cycle varieties, to compensate for late rains during the main rainy season and the shortening of this season [19]. These results are in line with those found in sub-Saharan Africa and South Asia, where the measures taken by farming households to adapt to climate variability are the adoption of improved crop varieties [33]. Migration is a strategy for adapting to the effects of climate change [34]. In Louga, mobility has always been a feature of the population, reflecting an ancient rural tradition where, during the dry season, one or more family members leave for the city to earn more income. Travelling is a necessity in order to earn enough money to support their families, start a family and improve the comfort of their homes [35].

5.4.3. Resilience Strategies Linked to Crop Diversification

Analyses show that 73% of farmers use cowpeas instead of groundnuts. This strategy would enable them to diversify their income. In Kelle Ndiaye, one farmer stated that “With the delayed rains, I use cowpeas instead of groundnuts because the cowpea cycle is shorter with the varieties ‘*yacine*’ and ‘*melax*’”. These results corroborate those of [36], who showed that crop diversification is a strategy used by producers to reduce the risk of crop losses due to climatic hazards. In Lubumbashi, 52% of farmers said that crop diversification offers a number of advantages, such as maintaining soil fertility, promoting integrated management of bioaggressors and providing greater income security for producers [37]. In Kenya, research has shown similar results, with farmers diversifying their production by changing varieties [38]. Similarly, the adverse consequences of climate change have prompted farmers in Burkina Faso to adopt adaptation strategies such as using soil and water conservation techniques (SWC) and changing sowing dates [39].

6. Conclusion

This study examined the impacts of climate change on groundnut (*Arachis hypogaea* L.) cultivation in the commune of Kelle Gueye in Louga, Senegal. The study found distinct links between climate variables and production indicators, with a strong positive correlation between temperature and yield. Although growers have different perceptions and resilience strategies regarding climatic disturbances, these are not statistically significant at the 0.05 threshold. In order to better respond to farmers’ needs, comparative trials should be set up to assess the effec-

tiveness of different agroecological practices and local varieties in terms of yield and resilience to climatic stress; other climatic and agroecological factors should be included in the analyses, as well as inter-seasonal variability.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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