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Agroclimatic Risks and Endogenous Knowledge of Farmers in the Guidimouni Basin (South-Central Zinder, Niger)

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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ABSTRACT

Agriculture is one of the most vulnerable sectors to the effects of climate change. The objective of this study is to analyze the impacts of rainfall variability on agricultural activities in the Guidimouni basin. The methodology used is based on the processing and analysis of daily rainfall data (Mirriah and Gouré stations from 1961 to 2019). It is complemented by a survey on perceptions of agroclimatic risks, impacts and strategies among a sample of 150 farmers in four villages. The results show that farmers have a good understanding of climate risks (80%) and are developing resilience strategies. These range from the intensification of irrigated crops (40%) to the use of natron (58%). In addition to these responses, the processing of products, particularly cassava (86%), and seasonal migration to Nigeria (28%) were also considered.

Keywords: Cuvette; risks; impacts; producers; adaptation.

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1. INTRODUCTION

In the Sahel, agricultural activity is a real problem because the determining factor, "rainfall," is undergoing a real change According to the work of [1,2], in West and Central Africa, these climate disturbances are manifested by a generally significant decrease in annual rainfall, with rainfall deficits of around 20% to 30%. This variability in rainfall leads to disturbances in agroclimatic parameters such as a decrease in cumulative rainfall [3]. The consequences are a regular and effective decrease of almost half of the production or yields of rainfed agriculture, both industrial and food crops [4]. Its impact on populations and their economies is devastating, leading to extreme vulnerability and reduced production [5-8]. Faced with seasonal disturbances, agricultural producers adopt a plurality of strategies in terms of responses to impacts. So, what are the risks resulting from disruptions in agroclimatic parameters for farmers in the basin? And what are the factors of climate resilience? The objective of this paper is to contribute to further documenting agroclimatic risks and coping strategies in agricultural settings in Sahelian basin zones in relation to endogenous knowledge.

1.1 Location of the Study Area

Located about 70 km east of the town of Zinder, between latitudes 9°30 and 9°34 North and longitudes 13°41 and 13°45 East, the rural commune of Guidimouni cover an area of 160 km2. It is bordered to the east by the rural commune of Guidiguir, to the west by those of Hamdara and Zermou, to the south by Bouné, Gouchi, and Wacha, and the north by the rural communes of Mazamni and Damagaram Takaya (Fig. 1).

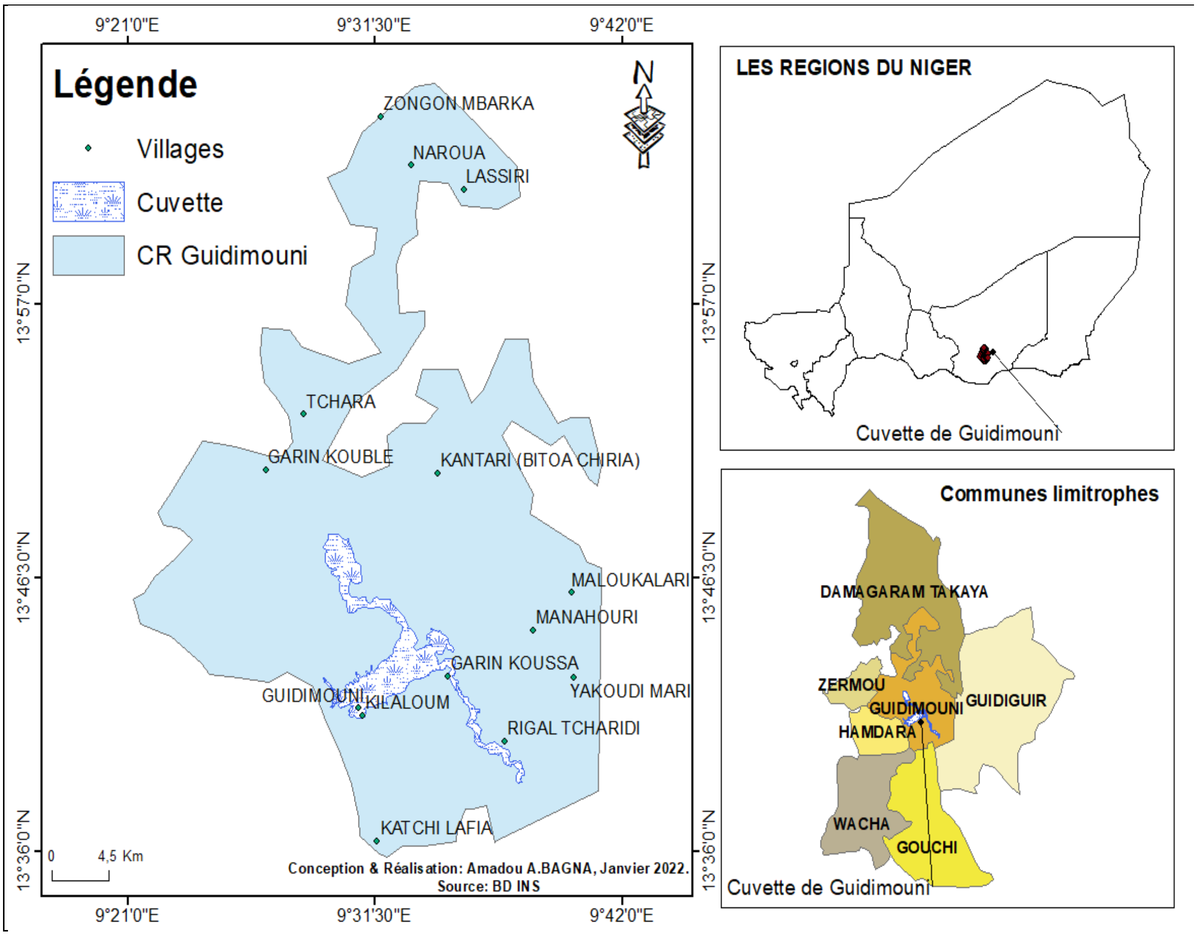

Fig. 1. Location map of the study area

2. DATA AND METHODS

2.1 Data Used

To analyze the longest possible rainfall series in the study area, two (02) synoptic stations (Mirriah and Gouré) were selected. They cover a period of 69 years from 1950 to 2019. They have no missing data, are daily and obtained from the National Directorate of Meteorology of Niger. Also, the choice of these series takes into account a long period before and after the onset of the 1972-1973 and 1984-1985 droughts in the Sahel and the 1961-1990 and 1991-2021 normal. In addition, information on perceptions and coping strategies was collected from a sample of 150 farmers. The criteria that guided the selection of the respondents were an average age of between 40 years and over, with a minimum of 10 to 20 years of experience in farming. These respondents were distributed among the villages of Guidimouni, Kilaloum, Chadika and Koussa. Thus, the sample size was determined using the Le Maux (2008) formula:

$$n = \frac{t^2 \times p(1-pi)}{e^2} \quad \text{(Eq. 1)}$$

Where n is the required sample size, t = 1.96 is the value of the normal random variable for a risk α equal to 0.05, pi is the estimated proportion of the population with the characteristic under study (75%), and e is the margin of error traditionally set at 0.05.

2.2 Methods and Tools

To assess the evolution of rainfall during the different years of the study period, the Nicholson rainfall index was calculated. This index is defined as a reduced centered variable expressed by equation 2:

$$I = \frac{(xi - \overline{x})}{\sigma\,(x)} \quad \text{(Eq. 2)}$$

With xi: rainfall of year i; x: average interannual rainfall over the reference period; $\boldsymbol{\sigma}\ (\boldsymbol{x})$: standard deviation of interannual rainfall over the reference period. Furthermore, the study of climate change highlights the need to analyze the internal structure of time series and their possible non-stationarity (PETTITT test (1979) and the MANN-KENDALL test (1945). Finally, Sphinx V5 was used to process the survey data.

3. RESULTS AND DISCUSSION

3.1 Evolution of Cumulative Rainfall: Alternation of Deficit Years and Surplus Years

The rainfall index 1950-2019, coupled with the linear trend curve, identifies the highly random nature of the rainfall. Fig. 2a shows the interannual evolution of the rainfall indices of Mirriah based on the fluctuations between dry and wet years. It is also found that the periods of decrease are more continuous and sustained than the periods of increase. In addition, the linear trend curve representing annual accumulations is decreasing: the average annual rainfall decreases from 652.1 mm in 1950 to 497.9 mm in 2019, passing respectively during the drought years of 1972-1973 and 1984-1985 to 339.39 mm and 280.79 mm Comparison of the pre-1980 interannual rainfall to the 1980-2019 period reflects an 18% difference at the Gouré synoptic station (Fig. 2b). The period 1950-2019 is marked by two strongly deficit years: 1976 and 1983. After 1970, there is an increase not only in the frequency of dry years but also in the amplitude of climatic dryness (Fig. 2a and 2b). The 1980s are particularly dry with the peak of the drought in 1983 and 1984. The 1990s appear to be wet, but with smaller amplitudes than in the 1950-1960 decade. The last decade is entering a surplus phase (wet phase) because since 2000, apart from the years 2003, 2004, and 2005, which are dry, all other years are wet. These results are confirmed by the work of [9].

In the Sahel, the drought of the 1970s was characterized mainly by a significant geographical extension and by a succession of fairly numerous deficit years [2,10,8]. The analysis of the indices of the two stations for the period (1950-2019) is a translation that highlights several periods of drought or rainfall surplus that have persisted for at least five successive years and more: deficits from 1966 to 1996 (30 years) from 1970 to 1974, wet periods1961-2008, surpluses from 1950 to 1960 (10 years) and 1998-2019 finally a new period return to wetter conditions from 2008 for the station of Mirriah, but characterized by a strong interannual variability (Fig. 2a and 2b). These results are shared by the work of [3,10], which showed alternating dry and wet periods at several stations in the Sahelian zone after the great drought of 1972-1973.

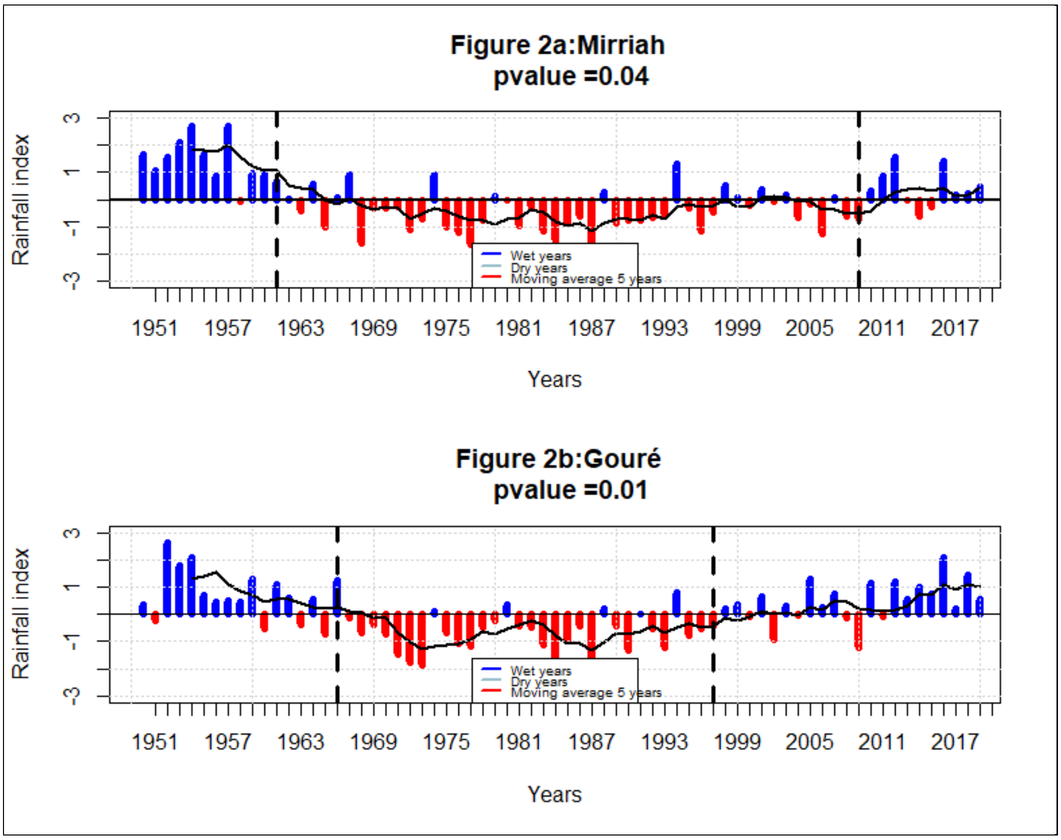

Fig. 2. Interannual evolution of rainfall anomalies at Mirriah (top) and Gouré (bottom)

3.2 Perceptions of Agroclimatic Risks on Production Activities

The main perceptions of rainfall variability among farmers in the four villages surveyed refer to the poor distribution of rainfall (82%) and the shortening of the rainy season. In addition, the impacts of rainfall variability differ according to the period. Parameters such as rural exodus (75%) and the length of the rainy season (48%) have higher intensities during 1961-1990 normal compared to the last 30 years. However, the populations surveyed consider that irrigated crops, natron exploitation, soil degradation and lower agricultural yields are more intense during 1991-2020 normal than during the first. These different impacts on production systems are indicative of the climatic crises in this zone over the past three decades.

Also, investigations among farmers reveal other impacts such as the loss of seedlings (48%), and the progressive silting up of the basin (34%), thus narrowing the areas for flood crops and potentially compromising the exploitation of the salt pans in the long term.

3.3 Various Adaptation Strategies to Reduce Risks

Faced with the uncertainties of the climate and the good perception of rainfall variability, producers are adopting conservative and regulatory strategies and attitudes.

3.4 Exploitation of Natron in Periods of Flooding

In the Guidimouni basin, exploitation of natron began around 1900 according to Vooetlin (1950) cited by [11,12]. However, with the droughts of the 1970s, only 28% of the basin was exploited, in 1980 (58%) and 2019, 72% of the sites were developed. It should be noted that the extraction of natron has taken on a significant scale and the sale has enabled the populations to cope with these serious food crises. Photos 1 and 2 show the natron exploitation sites in the Guidimouni basin. Thus, several actors are involved in the exploitation, including rainfed and irrigated farmers.

Photos 1 and 2. Natron exploitation sites in the Guidimouni
Taken by: A A. BAGNA, December 2021

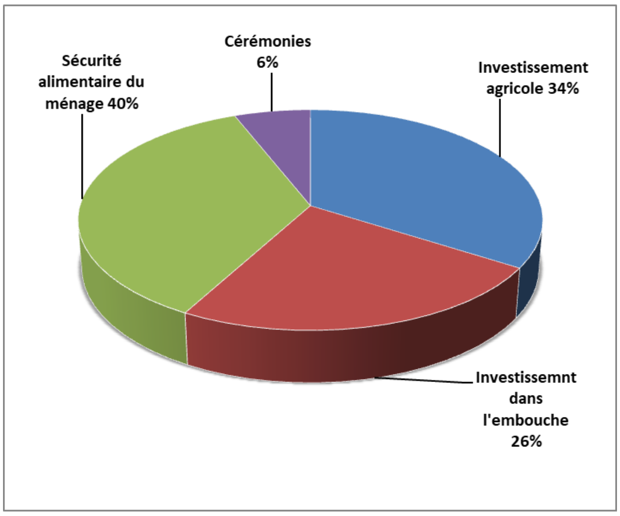

Fig. 3. Use of income from the sale of natron
Source: Field survey data, October 2021

Nowadays, the farm plays a double role. Firstly, the income from the marketing of this product helps to correct the recurrent cereal deficits due to the low productivity of the croplands and the climatic deterioration. As for the income from the sale, it contributes to investments. Most of this income is used for the agricultural sector (purchase of equipment and inputs) with 34% and fattening or purchase of livestock as a form of savings for the family (26%), but also, above all, for food security through the strengthening of producers' household budgets (40%) and ceremonies (6%) (Fig. 3).

3.5 Seasonal Youth Migration to Nigeria

In Niger, the movement of rural youth to large cities in the interior of the country and even to the coast after the harvest is a very old practice. Until the early 2000s, this practice only concerned a handful of young people who travel to Nigeria at the end of the harvest each year. However, since 2005, this movement seems to have intensified and has become more widespread with the poor harvests. In the rural commune of Guidimouni, this migration concerns 28% of young people. In fact, their destinations in Nigeria are the cities of Kano, Daura and Lagos (Field survey, October 2021). In the host countries, the main activities they engage in are selling tea, working in bakeries with traditional ovens, and working as shoemakers. The income from this migration is invested in the preparation for the next rainy season (purchase of seeds) and the strengthening of livelihoods. Those who manage to make a significant profit buy new irrigation kits

Photos 3 and 4. Irrigated maize and cassava fields in Guidimouni (Taken by A. BAGNA, December 2021)

for flood-recession crops. It should also be noted that migration as an adaptation strategy in the face of climatic shocks has been the subject of abundant literature in developing countries, particularly in the Sahel. From then on, in order to secure the livelihoods of Sahelian populations, seasonal migration appears to be an adaptation strategy to climate variability. These results are shared by [5,13,14,6], who have shown that in the Sahel, seasonal migration is precisely one of the farmers' strategies for managing shocks related to drought and food insecurity. These conclusions are reinforced by the results of [15], which considered migration as a measure of adaptation to climate variability and explained the acceleration of the migration phenomenon in the Sahel by environmental degradation and unfavourable climatic conditions.

3.6 Irrigated Crops and Processing of Agricultural Products

In the Guidimouni basin, there has been a revival in the practice of irrigated crops. This is a result of the rainfall deficits of recent years. These different crops help to support household food security and, beyond that, provide additional income for producers (Photos 3 and 4). These flood recession or irrigated crops concern approximately 40% of households. The land devoted to this activity is family land, i.e., it has been inherited for generations [16-19].

Also, certain crops such as cassava are given to women who, with the support of the NGO OXFAM, process it into flour (32%). Thus, this processing aims to improve the capacities of women's organizations in order to have quality by-products with a long shelf life, but also to strengthen their food security and financial empowerment. In addition, the income from the sale of the products allows them to access the means of production for a climate change-resilient agriculture (Field survey, October 2021).

4. CONCLUSION

The present work has revealed a high degree of rainfall variability in the Mirriah and Gouré stations. Alternating years of rainfall deficits and surpluses are observed. These disruptions result in the disorganization of agricultural activities, particularly reseeding, leading to low production with impacts on food security and livelihoods. Farmers' perceptions of rainfall variability are consistent with trends in observed climate data. As a result, farmers are developing strategies through the use of their local knowledge.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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