Effects Of Climate Change On The Crop Management : The Case Of The Irrigated Rice Cropping Of Seberi (NIGER)

Abdoul-Aziz Niandou Sofietou[1], Ali Nouhou[1]*

1 Department of Geography, University Abdou Moumouni Niamey, Laboratory for Study and Research on Sahelo-Saharan Territories (LERTESS), Niamey, Rep. of Niger

*Corresponding author : nouhougeo@yahoo.de

DOI: 10.29322/IJSRP.15.11.2025.p16737
https://dx.doi.org/10.29322/IJSRP.15.11.2025.p16737

Paper Received Date: 29th October 2025
Paper Acceptance Date: 28th November 2025
Paper Publication Date: 2nd December 2025

Abstract- Because of its geographical situation, Niger is suffering from the extreme effects of climate change, which is impacting on its socio-economic development. Since the major droughts of the 1970s and 1980s, the State has strengthened the irrigation system, but climatic hazards are hampering farming practices and profitability. The aim of this research is to assess the effects of climate change on the functioning of the Sébéri AHA. The methodology used combines the use of climatic data and fieldwork through in situ observation and the collection of qualitative and quantitative data from 101 farmers, cooperative members and technical agents. Analysis of the climate data made it possible to measure farmers' perceptions of climate change indicators. These indicators can be seen in the late and early onset of the rainy season, desertification, rainfall deficits, extreme heat and violent winds, etc. Flooding, the drying out of certain plots of land, diseases and attacks by crop pests, etc. are the main manifestations of climate change in the AHA. However, human activities on the environment and farming systems are also contributing to the drop in yields. Faced with this situation, farmers are developing mitigation measures through diversification of activities (trade, livestock, fishing, rain-fed farming, etc.), the use of bio-pesticides, motor pumps and early varieties adapted to the area's climate.

Key words - Hydro-agricultural development, rice cropping, climate change, Sébéri, Niger

1. INTRODUCTION

The issue of the effects of climate change on agricultural production has been addressed by several studies in different contexts. The IPCC technical report (2022) on climate change highlights global warming of between 1.5°C and 2°C, leading to an increase in the frequency, intensity and severity of droughts, floods and heat waves, as well as a continued rise in sea levels. This increases the risk to food security from 'moderate' to 'high' in vulnerable regions, particularly in the Sahel. According to the authors (Wagadou, 2022; Abdou, 2020, Bertrand; 2014), global warming compromises the agricultural situation due to a number of constraints that reduce agricultural production and threaten rainfed crop yields. Agricultural produce is also threatened by pests.

These crop pests generally cause significant damage to off-season crops. Studies carried out in the Tillabéry region (Hassane, 2023; Hie, 2011, Abdou, 2020; Fehichitan, 2011) show that people perceive the effects of climate change through the existence of climatic risks, whereas sunshine and humidity (van Oort, 2018) are factors that affect flood recession crops. In this context, the likely returns on investment in small-scale irrigation across Africa are much higher than those for large-scale schemes in the African Union (2020). The projected returns for the latter were around 6%, compared with an average of 28% for small-scale irrigation. It is in this sense that the contribution of large- and small-scale irrigation has been addressed by several studies (Waziri Mato, 2000; Kailou, 2020; Abdoul-karim, 2011; Fréderic. 2017; Oumarou, 2023).

For these authors, large-scale irrigation is one of the solutions favoured by countries and donors to meet the challenge of food insecurity and to manage the risks associated with the improbability of rainfall in the Sahel. The contribution of large-scale rice irrigation to the local and national economy, and the benefits in terms of food security and poverty reduction, remain largely undervalued. For example, the Say 2nd irrigated area produces an average of 1,869.28 tonnes of paddy rice per year. Over the past 30 years, Niger has suffered numerous droughts, floods, locust invasions and other parasitic attacks, leading to a drop in production and leaving the population food insecure. Indeed, the Sahel is one of the areas most exposed to the effects of climate change CNEDD (2015). Following the droughts of 1974, agricultural activities in Niger focused heavily on irrigated farming. As a result, a number of hydro-agricultural schemes for rice production were created along the River Niger.

The Sébéri development is one such AHA, located in the department of Kollo, 3 km from the town of Kollo. This AHA suffers from the effects of climate change (irrigation problems, flooding, strong winds, increased heat and attacks by crop pests), which undermine its sustainable operation. In this sense, Bagna et al (2016) have shown that climate change is one of the greatest challenges facing humanity. Other threats hindering the perimeter are its inefficient management and the production system. This article analyses the effects of climate change, the links between production systems and yield decline, and the strategies developed to mitigate the effects of climate change on the functioning of the Sébéri AHA, through a mixed (quantitative and qualitative) study. The main hypothesis is that climate change has a direct influence on the functioning of the Sébéri irrigated perimeter through high temperatures and rainfall, as well as drought.

2. METHODOLOGY

2.1 STUDY AREA

The study area is located in the commune of Kollo (Tillabery region), between latitudes 13°11’ and 13°25’ north and between longitudes 2°17’ and 2°27’ east. It lies around 34 km south-east of Niamey, the capital of Niger. Kollo is not only the capital of this commune, but also the capital of the department. The commune covers an area of around 750 km². It is bordered to the north by the district of N'Dounga, to the west by the River Niger, to the south by the district of Kirtachi and to the east and south-east by the district of Kouré.

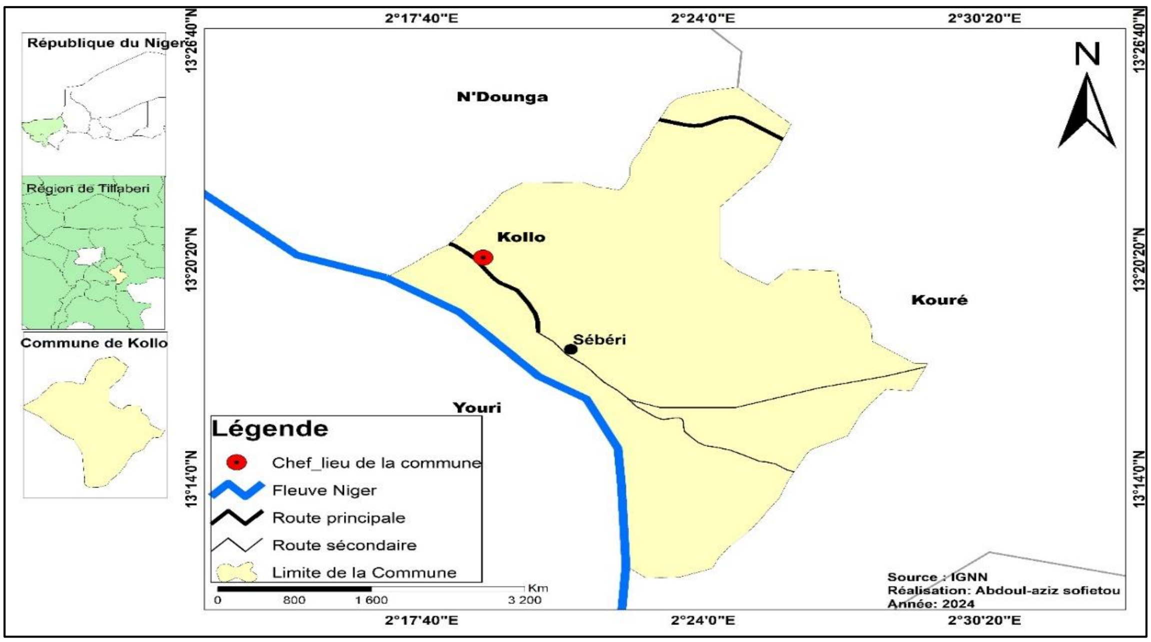

Fig. 1. Location of study the area

The choice of our study is explained by the fact that the combined effects of anthropogenic pressure and climate change on the functioning of the hydro-agricultural infrastructure of Sébéri has been less taken into account by previous studies. Given its geographical position in the river's flood zone, it is increasingly confronted with the phenomenon of climate change and the frequency of river flooding, thus hampering its proper functioning. As a result, farmers in the area are highly vulnerable to food shortages. The main aim of this study is to assess the effects of climate change on the functioning of the Séberi hydro-agricultural scheme (commune of Kollo). It then seeks to highlight the strategies developed by farmers to adapt to the various impacts of climate change on their socio-economic living conditions.

2.2 Methodological approach

A mixed method was used in this study. Two types of data were collected in the field. These were quantitative data and qualitative data. Quantitative data were collected using a questionnaire sent to farmers in the Sébéri area. We sent four (4) interview guides to the stakeholders (the president of the cooperative, the perimeter manager, a woman parboiler and the pump operator). The simple random sampling technique was used. A margin of error of 10% was used to determine the representative sample of the whole population.

3. RESULTS

3.1 Description of the rice cropping perimeter of Seberi

Situated about 3 km from the town of Kollo, the area has an 8 km-long eastern dike, 9.75 ha of nurseries and 371.12 ha of rice fields. The perimeter is bounded to the west by crop fields, houses, etc., and to the south-east by the river, the protective dyke on which the pumping station is located and a canal leading to the river.

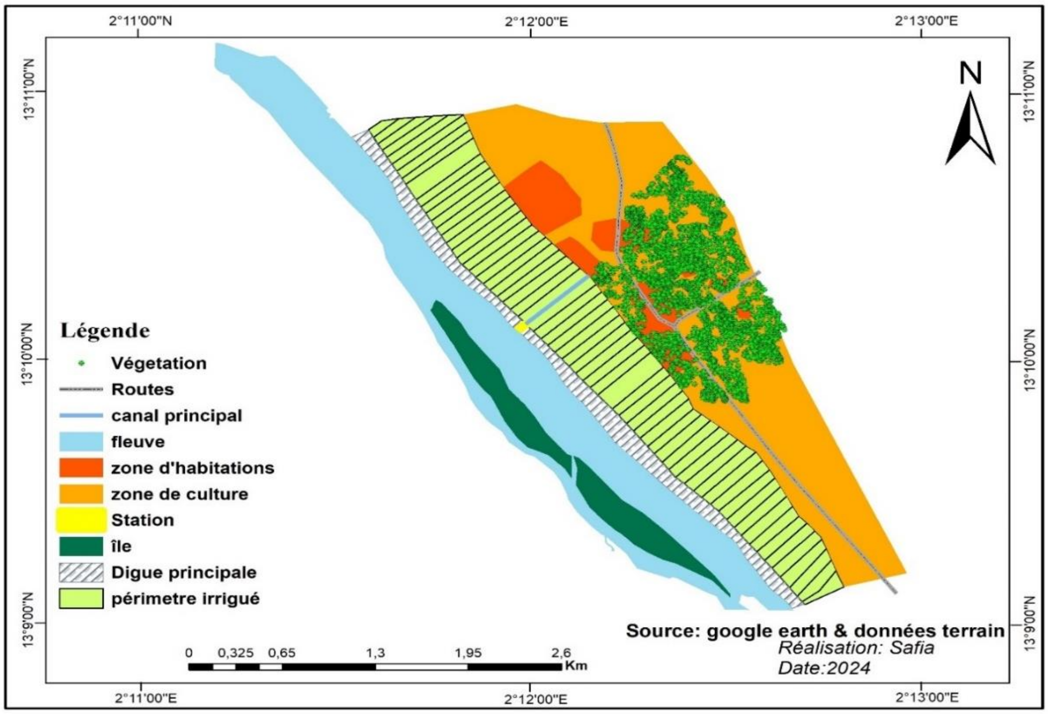

Fig. 2. The rice cropping perimeter of Seberi and its land use
Source : goggle earth

3.2 Analysis of the rainfall data

Rainfall in the study area is characterised by strong spatio-temporal variation. Rainfall generates surface water resources that make irrigation possible, particularly for rice growing. Figure 6 shows changes in rainfall in the study area between 1998 and 2023. With a slightly downward trend, analysis of this figure shows 17 years of deficit compared with 9 years of surplus. The maximum in the series was observed in 1998, with cumulative rainfall of around 857 mm, and the minimum was recorded in 2011, with 337 mm.

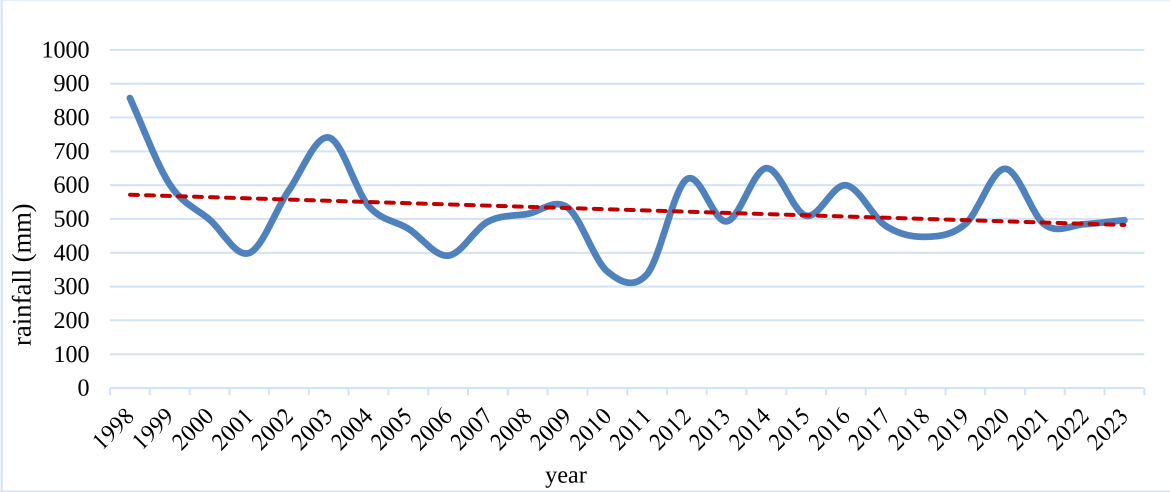

Fig. 3. Rainfall trends in Kollo from 1998 to 2023
Source: DDA Kollo, 2023

3.3 Analysis of temperature data

Temperature is one of the characteristics of the Sahelian zone. The climate in Kollo department is characterised by a hot period from February to June, with maximum temperatures reaching 45°C (DDA-Kollo, 2023). Figure 7 shows the inter-annual trend in maximum temperatures, with an upward trend from 1993 to 2009. There was little variation in the average maximum temperature, ranging from 43°C to 44°C, a difference of around 1°C on average. The annual maximum temperature varies from 45.5°C in 2010 to 45.03°C in 2019. However, the trend has been upwarded right up to the present day.

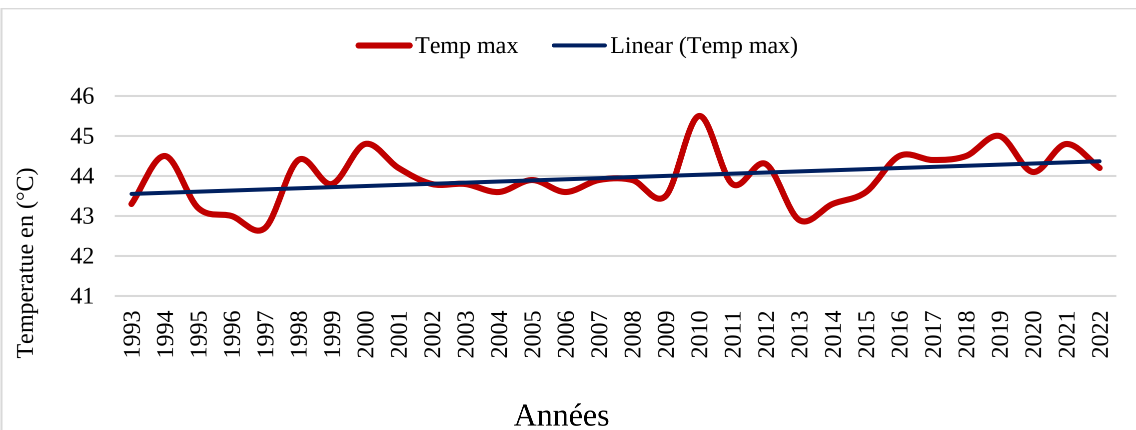

Fig. 4. Changes in maximum temperature from 1993 to 2022
Source: NASA statistics, 2024

3.4. Analysis of river flow trends

As the commune does not have a flow measurement station, we used data from the Niamey station, which are comparable to those in the study area. Following on from this, we feel it is important to take ten years (2011-2020) out of 46 years to show the flows that may or may not cause flooding. The hydrograph shows that the highest flow is recorded in 2020 with 2223 m3/s caused by the local flood in September. This caused huge losses for the population (agricultural production, human life, material goods, etc.). In contrast, in May 2018, the flow was 9 m3/s, coinciding with the low-water period, which caused irrigation problems.

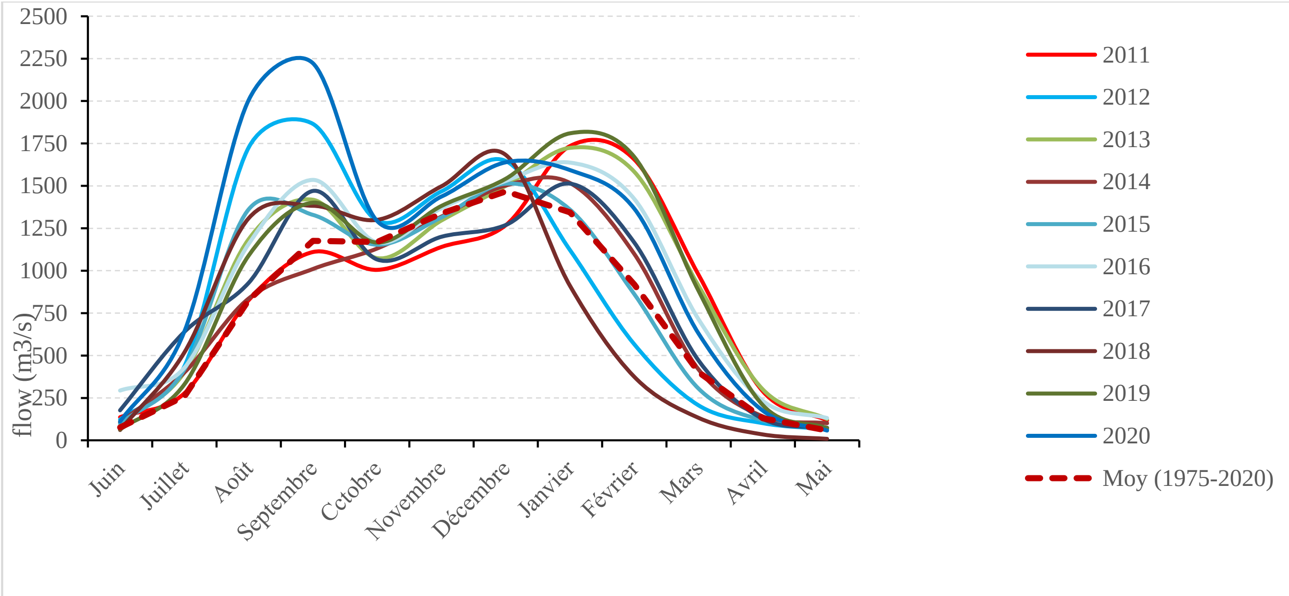

Fig. 5. Trends in hydro grams of crude from 2011 to 2020 compared with the average for the period 1975-2020
Source : ABN 2023

3.5 Impact of climate change on the cropping calendar

The impact of climate change on the cropping calendar can be seen in the disruption of pre-programmed periods for rice-growing activities in the perimeter. Table 1 shows that, because of the presence of water in certain plots, sowing is postponed for weeks or even months, while others bring forward sowing to avoid irrigation problems for the dry season (SS). In the SH season, work is not disrupted because most of the irrigation is provided by rainfall. Rainfall not only facilitates irrigation in terms of labour, but also in terms of the time spent irrigating. On the other hand, because man has no control over this rainfall, its irregularity hampers the development of rice (plots drying out, flooding) and yields fall. So climate change has disrupted compliance with this cropping calendar, with heavy rainfall changing the dates set by experts for rice production.

Table 1: Theoretical rice cropping calendar for the Sébéri irrigated perimeter for the two cropping seasons

Calender											
Dry season campaign (SS)											
Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Mai	Jun	Jul	Aug
Campaign od the rainy season (SH)											
Apr	Mai	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Fev	Mars
		Sowing	nursery	transplanting	In the field		harvesting				

Source ONAHA/DMV, 2023

3.6 Rice varieties grown by farmers

The results show that several rice varieties are used in the perimeter, including Guiza, IR15, Gambiaca and others. The most commonly used variety is Gambiaka, which accounts for 50%, compared with 10% for the other varieties (Jamila, Mai alewa, Sébéri, Wayhijo, Séba tibo). Around 88% of farmers buy these varieties from the cooperative or through FUCOPRI, while 3% buy from traders or exchange varieties between themselves. Gambiaka, Guiza and IR15 are registered varieties. However, growers use released varieties (Guiza, IR15, Gambiaka) more than other or local varieties. Gambiaka is the variety that is most resistant to pests and excess water in the winter season.

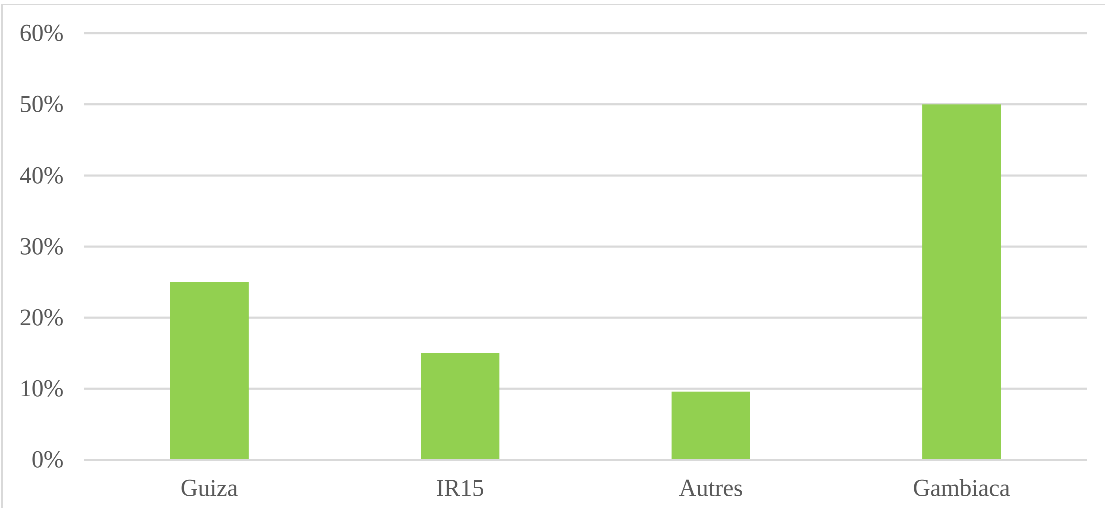

Fig. 6. Types of varieties used by farmers
Source: field survey, 2023

3.7. Rice production yields in the perimeter

Figure 7 shows a trend towards improved productivity, which was suddenly halted by the flood of 2020. The highest yields are obtained in 2021 and 2022 and the lowest in 2017 and 2019. According to the survey, the wet season (SH) is the period during which 'we don't put too much effort into irrigating our plots, but yields are not up to scratch because of disease and flooding of plots that don't need water because of the unpredictability of rainfall'.

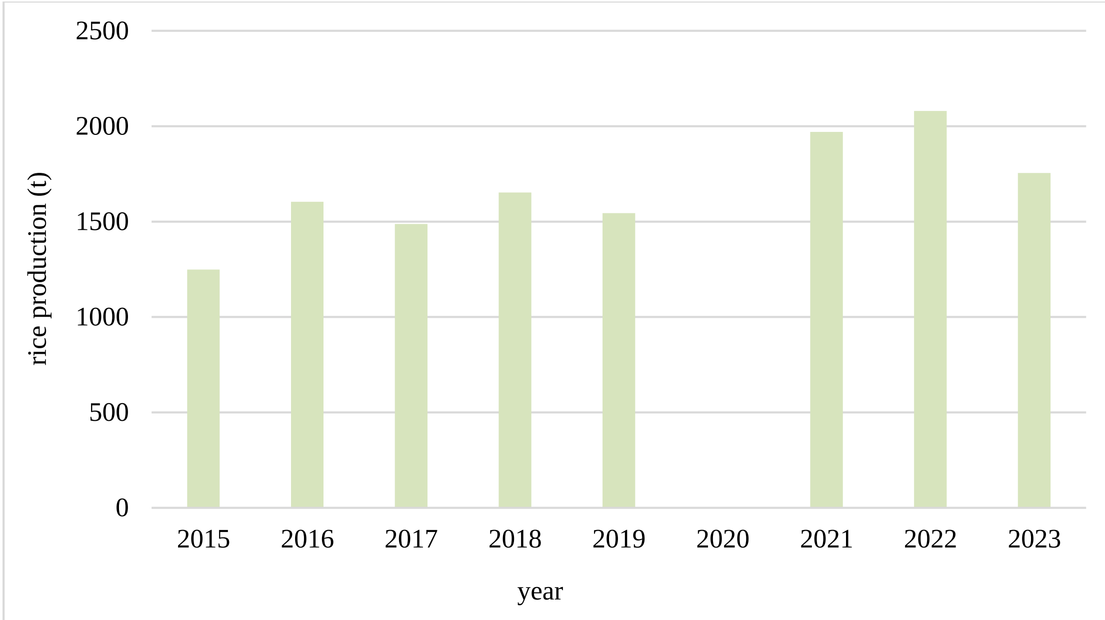

Fig. 7. Rice production yields in SH from 2015 to 2023
Source: ONAHA/DMV, 2023

4. Discussion

Respondents' perceptions of the effects of climate change on the irrigated perimeter are reflected in higher temperatures, violent winds and spatio-temporal variability in rainfall. Local people remember abundant, regular rainfall and long-lasting rains in the past. They say that 'as soon as we saw clouds in the sky, we were sure it was going to rain, while others do the semi-dry'. The consequences of climate change are severalfold, the most important of which is the drop in agricultural production, particularly rice yields. The effects of climate change can be seen in soil degradation, desertification, rainfall deficits, drought, flooding, etc. .... These results are similar to those obtained by Agossou (2012), who showed that the indicators of climate change include the extension of the dry season, the late start and early end of the rainy season, and the uneven distribution of rainfall in space and time. The impacts of climate change on the functioning of the Sebéri AHA can be explained by direct climatic parameters such as sunshine, high or low temperatures (van Oort, 2018) and winds. Indirect effects include irrigation problems, flooding, attacks by crop pests and disruption of the cropping calendar.

These climate change factors are combined with human activities, which further exacerbate climate change, and the lack of infrastructure (drains, canals). These results are similar to those of the authors (Ahmadou et al. 2022; Feyichitan, 2011), who stress that factors such as temperature, solar radiation and wind influence rice yield through their effects on growth and the physiological processes involved in rice formation, as well as indirect factors such as diseases and pests. The most widely used rice varieties are Gambiaka and Guiza, all improved varieties. These results are less in harmony with those of Seydou et al (2022), who show that farmers in the Saga irrigated perimeter use five varieties (Gambiaka, IR15,) released and three local varieties (Weyhidjo, N1, N2). Similarly, Mahamadou (2015) looks at rice production systems outside the AHA in the rural communes of Zabori and Karakara. He shows that the main fertilisers used are NPK (15, 15.15) and urea, which is used as a supplement to ensure good crop development.

Aware of the impact of climate change on the functioning of the Sebéri AHA, farmers have implemented adaptation measures, the most suitable strategy being the diversification of economic activities, which generates income for the population in the event of a poor harvest and therefore reduces their vulnerability to climate risks. These results are less similar to those found by CILSS researchers (2010), who add that other strategies that are not widely used include crop diversification, agroforestry and irrigation. Faced with the various risks associated with climate variability (drought, wind, crop pests, flooding, etc.), which result in a reduction in agricultural and fodder production, farmers develop a number of adaptation strategies.

5. Conclusion

The effects of climate change can be seen in several parameters on the hydro-agricultural development of Sébéri. These include sunshine or extreme heat, violent winds, early low water levels in the river, irregular rainfall and soil degradation. These effects result in irrigation problems, flooding and the appearance of crop pests (worms, birds). Anthropogenic action on the environment, in particular excessive use of chemicals and clearing of trees, leads to land degradation. Moreover, the production systems (inputs and tools) used by farmers are based almost entirely on extensive or traditional systems, which are less efficient even though they use approved varieties. In addition, these systems and the inefficient management of the perimeter are a constraint on the proper development of the perimeter's activity. However, regarding all these factors, which have led to a drop in yields in the perimeter, farmers have implemented adaptation measures. These strategies include diversifying their activities, trading, storing their harvests, using motor pumps and bio-pesticides, etc.

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