

RESEARCH ARTICLE

EFFECTS OF CLIMATE EXTREMES ON FAMILY FARMING IN THE COMMUNE OF OUINHI, SOUTHERN BENIN

^{3,*}OGOUWALE Romaric, ^{1,2}AHOMADIKPOHOU Dèdègbê Dèdègbê Louis and
^{1,3}DOVENON Vincent Kossi

¹Rural Geography and Agricultural Expertise Laboratory (LaGREA) / University of Abomey-Calavi (BENIN)

²Institute of Living Environment (ICaV), University of Abomey-Calavi (BENIN)

³Pierre Pagney Laboratory "Climate, Water, Ecosystem and Development", 04 BP 529 Cotonou, Benin

ARTICLE INFO

Article History:

Received 20th June, 2026

Received in revised form

24th July, 2026

Accepted 19th August, 2026

Published online 30th September, 2026

Key words:

Climate extremes, family farming, correlation, SPI, STI, Ouinhi, Benin.

*Corresponding author:

OGOUWALE Romaric

ABSTRACT

Extreme climatic events represent a major constraint for rain-dependent family farming in tropical areas. This study analyses the effects of climate extremes on family farming in the Commune of Ouinhi, southern Benin, through rainfall and temperature variability, their impacts on agricultural yields and household livelihoods, and the statistical correlation between these parameters. The methodological approach relies on daily climatic data covering the 1990-2023 period and survey data collected from 125 farming households and 37 resource persons across the four districts of the Commune of Ouinhi. The Standardized Precipitation Index (SPI) and the Standardized Temperature Index (STI) were used to characterize climatic variability, while Pearson's correlation coefficient, computed in R, assessed the relationship between these indices and maize and cassava production. The results show that the SPI ranges between -1.6 and +2.1 with no significant linear trend ($R^2 = 0.012$), reflecting an irregular alternation of wet and dry years. The STI reveals a climatic shift from 2006 onward, marked by a continuous dominance of warm years. Maize production rose until 2010-2011 (over 20,000 tonnes) before collapsing sharply in 2011-2012, whereas cassava, more resilient, remained between 80,000 and 112,000 tonnes over the period. Pearson correlation coefficients between climatic indices and agricultural production remain weak and statistically non-significant ($|r| \leq 0.38$; $p > 0.05$), suggesting that agricultural impacts stem more from the crossing of critical thresholds during extreme years than from a continuous linear relationship with climatic parameters. A generalized decline in financial, social and natural livelihood capitals between 2004 and 2024 further reflects the growing vulnerability of farming households. Strengthening water control, crop diversification and institutional support to farmers are essential levers for improving the resilience of family farming to climate extremes in Ouinhi.

Citation: OGOUWALE Romaric, AHOMADIKPOHOU Dèdègbê Dèdègbê Louis and DOVENON Vincent Kossi. 2026. "Effects of climate extremes on family farming in the commune of ouinhi, southern benin.", *Asian Journal of Science and Technology*, 17, (09), 14487-14491.

Copyright©2026, OGOUWALE Romaric et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

INTRODUCTION

Agriculture constitutes the foundation of global food security and the leading sector generating employment and income in developing countries (World Bank, 2018). However, it remains increasingly exposed to extreme climatic events such as prolonged droughts, devastating floods and intense heat waves (IPCC, 2022), which exacerbate the vulnerability of family farms whose adaptive capacities remain limited. Like most West African countries, Benin experiences increasingly pronounced rainfall variability, alternating between drought episodes and floods (Ozer, 2010). The Commune of Ouinhi, located in the Zou department, is one of the main food-producing areas of southern Benin. Despite generally favorable ecological conditions, its agricultural yields follow an irregular trend, in which climatic instability plays a central role, since production relies essentially on seasonal rainfall

(Issa, 2012). The irregularity of total rainfall, the increased frequency of dry or wet sequences during the rainy season, and the shortening of the rainy season compromise cropping calendars and yields (Adjakpa, 2020). Although the adaptation strategies developed by farmers in Ouinhi have already been the subject of a detailed analysis, the statistical characterization of the link between climatic parameters and agricultural production remains little explored there. The present study therefore proposes to analyze the effects of climate extremes on family farming in the Commune of Ouinhi. Specifically, it aims to characterize the Commune's rainfall and temperature variability, to assess the impacts of this variability on maize and cassava yields as well as on household livelihoods, and to evaluate, using a correlation analysis carried out in the R software, the degree of association between climatic parameters and agricultural production.

Study Area: Located between 6°37'36" and 7°12'0" north latitude and between 2°19'12" and 2°38'24" east longitude, the Commune of Ouinhi is bordered to the northwest by the Commune of Zagnanado, to the southwest by the Commune of Zogbodomey, to the south by the Ouémé department, and to the east by the Plateau department. It covers an area of 483 km² and comprises 40 villages and town districts spread across four arrondissements: Ouinhi, Dasso, Sagon and Tohouè (Zannou and Tchaou, 2022). Figure 1 shows the geographic and administrative location of the Commune of Ouinhi.

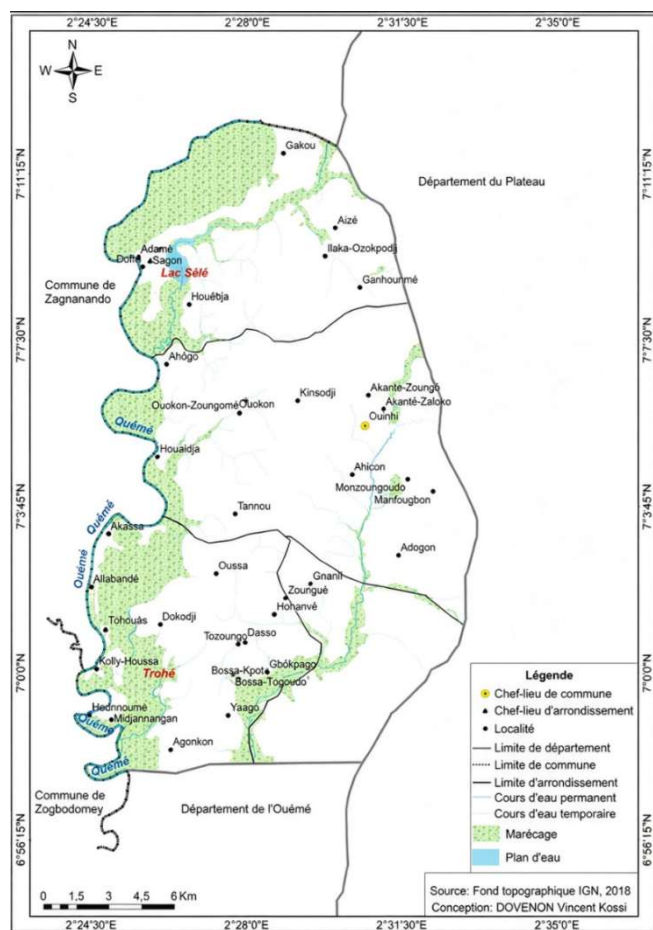


Figure 1. Geographic and administrative location of the Commune of Ouinhi

The Commune of Ouinhi has a transitional climate between the subequatorial and humid tropical Sudano-Guinean type, with four distinct seasons and a bimodal rainfall regime one year in three, characterized by two rainfall peaks in June and September. Average annual rainfall is 1,045.5 mm, spread over about 90 rainy days. The hydrographic network, dominated by the Ouémé River and its tributaries, provides abundant water availability but strongly exposes the arrondissements of Sagon and Tohouè to flooding. In terms of soils, the Commune is dominated by hydromorphic vertisols, mineral hydromorphic soils and weakly desaturated ferralitic soils, whose fertility directly conditions agriculture's capacity to adapt to climate extremes. Demographically, the population of Ouinhi rose from 22,287 inhabitants in 1979 to 59,853 inhabitants in 2013, an average annual growth rate of about 3.5%, placing growing pressure on land resources. Agriculture remains the main socioeconomic activity, practiced by 79% of households, well ahead of livestock farming (47%) and trade (21%). Inheritance is the main mode of land access (45% of

respondents), followed by purchase (23%) and rental (17%), reflecting a gradual monetization of agricultural land.

Methodological Approach

Data Collection: The data used combine a documentary review, a field survey by questionnaire among farming households, and semi-structured interviews with resource persons. The household sample size was determined using Schwarz's formula (1995):

$$N = z^2 \times p \times (1 - p) / i^2$$

Where Z is the confidence level (1.96 for 95%), p the proportion of farming households in the Commune ($p = 9.39\%$ according to RGP4, 2013), and i the desired margin of error (5%). This formula yielded a sample of 125 farming households, distributed across the four arrondissements according to their respective demographic weight (Table I). Thirty-seven resource persons (local elected officials, ATDA officers, NGO representatives) were also interviewed to collect qualitative data on climatic manifestations and local responses.

Table I: Distribution of the surveyed sample in the Commune of Ouinhi

District	Farming households	Households surveyed
Dasso	1,578	31
Sagon	2,096	41
Tohouè	1,047	21
Ouinhi	1,671	32
Total	6,392	125

Source: Adapted from field survey data, DOVENON (2026)

Data Processing and Analysis: Survey responses were processed using the statistical protocol $P = (n/N) \times 100$, where n is the number of responses obtained for a given category and N is the sample size. Rainfall variability was characterized using the Standardized Precipitation Index (SPI), proposed by McKee *et al.* (1993):

$$SPI = (X - \mu) / \sigma$$

where X is the precipitation observed over the period, μ the mean precipitation, and σ the standard deviation of the series. A year is considered deficient when $SPI \leq -1$, normal when $-1 < SPI < 1$, and excess when $SPI \geq 1$.

Temperature variability was analyzed using the Standardized Temperature Index (STI), calculated following a similar logic from mean annual temperatures, with a year classified as warm when $STI \geq 0$ and mild when $STI < 0$ (Faye *et al.*, 2019). The degree of association between climatic parameters and agricultural production was assessed using Pearson's linear correlation coefficient, computed in the R software (version 4.3, ggplot2 package) using the formula:

$$r = \Sigma(x_i - \bar{x})(y_i - \bar{y}) / \sqrt{[\Sigma(x_i - \bar{x})^2 \times \Sigma(y_i - \bar{y})^2]}$$

where x represents the values of the climatic index (SPI or STI) and y the annual agricultural production (maize or cassava), for the same reference year. The statistical significance of each coefficient was tested at the 5% threshold (Student's t-test, R's cor.test function). Scatter plots, regression lines and the correlation matrix were produced in R using the ggplot2 package, with a 95% confidence interval around each regression line.

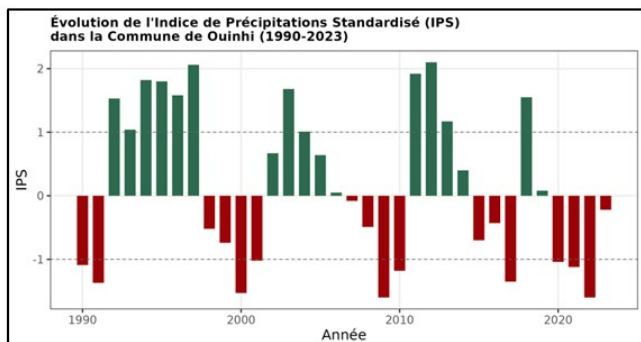
Table II: Pearson correlation coefficients between climatic parameters and agricultural production

Relationship tested	Period	Pearson's r	Significance (5% threshold)
SPI x Maize production	2004-2023	-0.28	Not significant ($p = 0.234$)
STI x Maize production	2004-2023	0.14	Not significant ($p = 0.568$)
SPI x Cassava production	2010-2023	0.14	Not significant ($p = 0.639$)
SPI x STI	1990-2023	-0.38	Not significant

Source: Authors, processed in R (*cor.test* function, Pearson method)

RESULTS

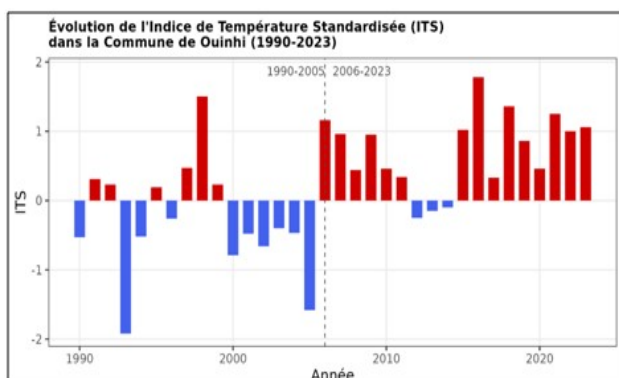
Rainfall Variability in the Commune of Ouinhi: Analysis of the SPI computed over the 1990-2023 period reveals strong interannual rainfall variability, with values ranging between -1.6 and +2.1 (Figure 2). The 1990-1999 decade is generally excess, whereas the 2000-2009 decade stands out for a marked deficit trend. The 2010-2019 period shows a rapid alternation of wet and dry years, and the 2020-2023 years are dominated by rainfall deficits. The trend line ($y = 0.0047x$; $R^2 = 0.012$) confirms the absence of any clear orientation toward lasting drying or wetting of the local climate: it is interannual variability, more than an underlying trend, that characterizes Ouinhi's rainfall regime.



Source: Authors, based on data from DOVENON (2026); processed in R

Figure 2. Trend of the Standardized Precipitation Index (SPI) in the Commune of Ouinhi (1990-2023)

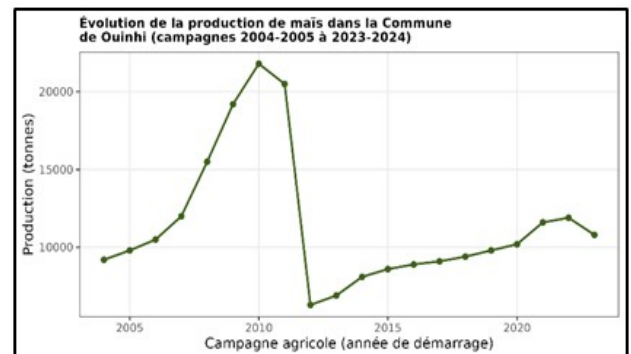
Temperature Variability in the Commune of Ouinhi: The trend in the STI reveals a clear climatic shift starting in 2006 (Figure 3). The 1990-2005 period is dominated by mild years ($STI < 0$), with marked lows in 1993 ($STI = -1.92$) and 2005 ($STI = -1.58$), interspersed with isolated peaks such as in 1998 ($STI = 1.50$). From 2006 onward, the index shifts durably into positive territory, except for a brief, weakly negative 2012-2014 sequence. The most recent decade (2015-2023) records the highest and most persistent values, with a historic peak in 2016 ($STI = 1.78$), confirming a recent intensification of warm conditions in the Commune.



Source: Authors, based on data from DOVENON (2026); processed in R

Figure 3. Trend of the Standardized Temperature Index (STI) in the Commune of Ouinhi (1990-2023)

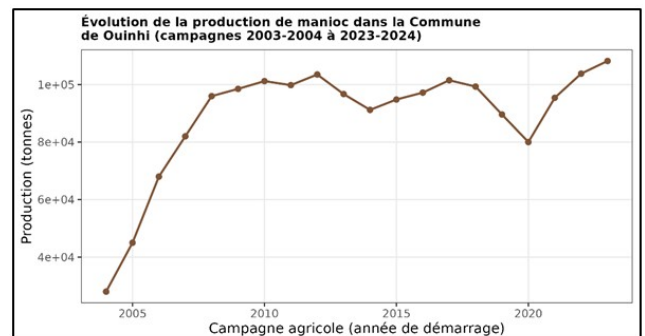
Impacts on Agricultural Yields: Maize production, the Commune's main cereal crop, underwent strong fluctuations between 2004 and 2024 (Figure 4). After a continuous rise between the 2008-2009 and 2010-2011 growing seasons, reaching over 20,000 tonnes, a sharp drop was recorded in 2011-2012, a period corresponding to a severe rainfall deficit. Production then stabilized between 8,000 and 10,000 tonnes from 2013-2014 onward, with a modest recovery around 2021-2022.



Source: Authors, based on DSA/DSI-MAEP, cited in DOVENON (2026); processed in R

Figure 4. Trend in maize production in the Commune of Ouinhi (2004-2024)

Cassava, the main tuber crop grown, shows a more resilient trajectory (Figure 5). After a phase of expansion between 2003-2004 (13,825 tonnes) and 2008-2009 (95,982 tonnes), production remained within a range of 80,000 to 112,000 tonnes until 2023-2024, with only one marked decline in 2021-2022 (80,006 tonnes). This relative stability confirms cassava's role as a buffer crop during periods of water stress.

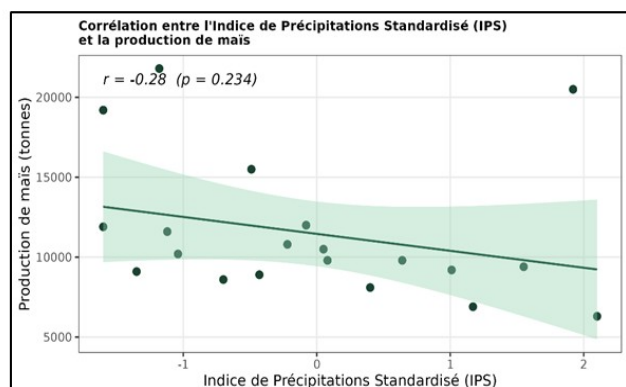


Source: Authors, based on DSA/DSI-MAEP, cited in DOVENON (2026); processed in R

Figure 5. Trend in cassava production in the Commune of Ouinhi (2003-2024)

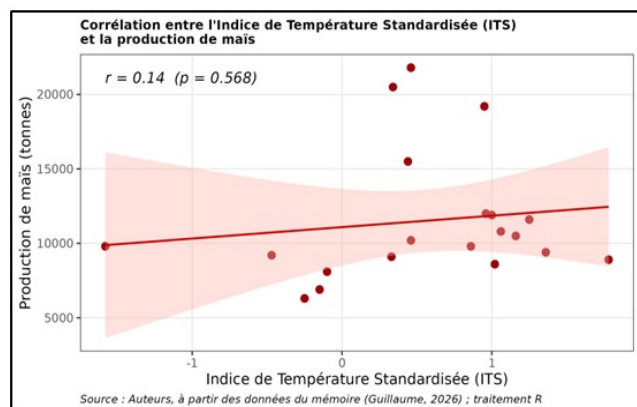
Correlation between Climatic Parameters and Agricultural Production: The correlation analysis, carried out in R, relates the climatic indices (SPI, STI) to annual maize and cassava production (Figures 6 to 9). The correlation between SPI and maize production is weak and negative ($r = -0.28$; $p = 0.234$), as is that between SPI and cassava production, calculated over

the stabilized production period 2010-2023 ($r = 0.14$; $p = 0.639$). The relationship between STI and maize production also remains weak ($r = 0.14$; $p = 0.568$). None of these coefficients reaches the 5% statistical significance threshold. The correlation matrix (Figure 9) confirms the general weakness of linear associations among the four variables. Only the relationship between SPI and STI shows a moderate coefficient ($r = -0.38$), reflecting a tendency for the rainiest years to be relatively less warm, although this relationship likewise does not reach the significance threshold. Table II summarizes all the coefficients obtained. These results indicate that the relationship between climate and agricultural



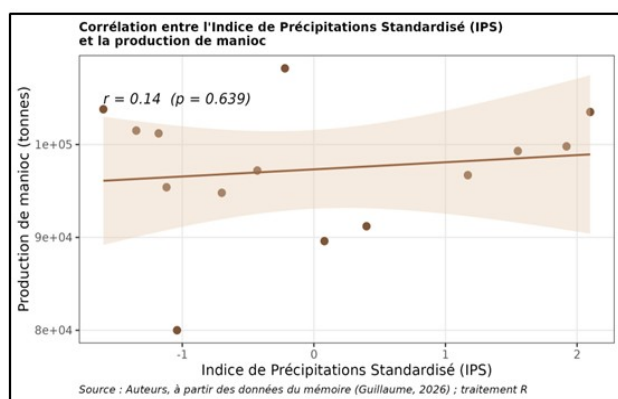
Source: Authors; processed in R

Figure 6. Correlation between SPI and maize production



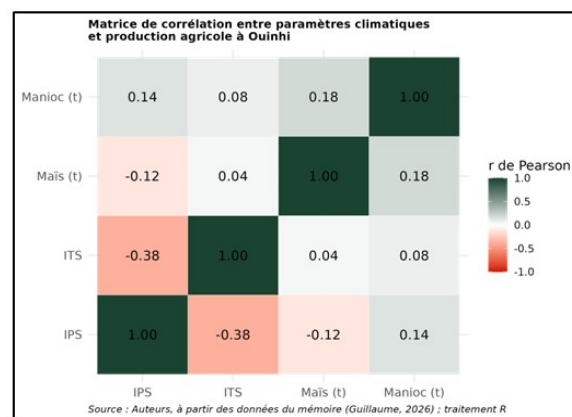
Source: Authors; processed in R

Figure 7. Correlation between STI and maize production



Source: Authors; processed in R

Figure 8. Correlation between SPI and cassava production (2010-2023)



Source: Authors; processed in R

Figure 9. Correlation matrix between climatic parameters and agricultural production in Ouinhi

production in Ouinhi is not continuously linear in nature. The most marked yield declines, notably the collapse of maize production in 2011-2012, correspond to years in which climatic indices cross a critical threshold (SPI or STI close to or beyond ± 1), rather than to a proportional relationship holding across the entire series. This finding is consistent with the class-based interpretation of the SPI and STI (deficient, normal, excess; mild, normal, warm), which better captures the discontinuous nature of climatic impacts on family farming than a simple linear model would.

Effects on Household Livelihoods: Analysis of the five livelihood capitals between 2004 and 2024 reveals a generalized deterioration in the living conditions of farming households. Financial capital and social capital show the sharpest declines, reflecting a loss of access to credit and a weakening of community solidarity. Physical capital and natural capital are also deteriorating under the effect of recurrent flooding and declining soil fertility. Only human capital remains relatively stable, sustained by farming experience and local knowledge accumulated by producers. This trend reflects a progressive weakening of the productive and social base of households in the face of the recurrence of climate extremes.

DISCUSSION

The strong interannual variability of the SPI observed in Ouinhi, without a marked linear trend, corroborates the work of McKee *et al.* (1993), for whom this index precisely highlights the alternation between dry and wet years rather than an underlying shift in the rainfall regime. The thermal shift observed from 2006 onward is also consistent with the findings of Faye *et al.* (2019) on rising average temperatures in West Africa and with IPCC (2022) projections on regional warming. The weakness of the linear correlations between climatic indices and agricultural production does not call into question the existence of a link between climate and agriculture in Ouinhi; rather, it reveals its non-linear, threshold-based nature. This finding is consistent with the observations of Mertz *et al.* (2009) in the Sahel, according to which farmers perceive and are most affected by extreme years rather than by a gradual climatic drift. The drop in maize production in 2011-2012 thus coincides with a severe rainfall deficit, while the relative resilience of cassava, a crop more tolerant of water stress, confirms the analyses of Vodounou and Onibon Doubogan (2016) on the buffering role of tubers

in Benin's family farming systems. Ouinhi's vulnerability to flooding, already documented by Yabi (2019), is explained by its proximity to the Ouémé River and by a topography that favors soil waterlogging. The leaching and compaction processes observed confirm the findings of Liu (2004) on the physico-chemical degradation of flooded soils in a humid tropical climate. Finally, the deterioration of financial and social livelihood capitals recorded in Ouinhi is consistent with the findings of Gbedji *et al.* (2022) and Dimon (2008), who link the recurrence of climatic hazards to a weakening of local economic and social resilience mechanisms, in the absence of sufficient institutional support for family farmers.

CONCLUSION

The analysis of the effects of climate extremes on family farming in the Commune of Ouinhi confirms strong rainfall variability and a marked thermal intensification since 2006. These climatic trends translate into pronounced but discontinuous impacts on agricultural yields, as illustrated by the sharp drop in maize production in 2011-2012, and into a progressive deterioration of household livelihoods. The correlation analysis carried out in R shows that these impacts result less from a continuous linear relationship with climatic indices than from the crossing of critical thresholds during the most extreme years, with cassava standing out for its relative resilience to these shocks. These results argue for strengthening water control in lowland areas, diversifying crops toward more resilient species, and increasing institutional support in terms of agricultural credit and land tenure security, in order to consolidate the resilience of family farming in the Commune of Ouinhi to the recurrence of climate extremes.

REFERENCES

ADJAKPA T. T. (2020): Variabilité pluviométrique et adaptation des producteurs d'arachide (*Arachis hypogea*) dans l'arrondissement de Dasso (Commune d'Ouinhi) au Bénin. *Revue de Géographie*, UAC.

World Bank (2018): *World Development Report 2018: Reshaping the Future*. Washington DC, World Bank.

DE MARTONNE E. (1926): Une nouvelle fonction climatologique: l'indice d'aridité. *Météorologie*, vol. 2, p. 449-459.

DIMON R. (2008) : Adaptation aux changements climatiques : perceptions, savoirs locaux et stratégies d'adaptation développées par les producteurs des Communes de Kandi et de Banikoara, au Nord du Bénin. Thèse de Doctorat, UAC.

FAYE M., FALL A. et TINE D. (2019): Évolution pluviométrique de 1950 à 2013 au Sénégal oriental: cas de la région de Tambacounda. *International Journal of Advanced Research*, vol. 7, n° 12, p. 270-287.

GBEDJI B. G., ISSA M.-S. et OGOUWALE E. (2022) : Stratégies d'adaptation des entrepreneurs en agrobusiness aux contraintes climatiques dans les Communes d'Adjohoun et de Bonou au sud du Bénin. *LECREDE/FLASH/EDP/UAC*.

IPCC (2022): *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the IPCC*, Geneva.

DOVENON K. (2026) : Stratégies d'adaptation de l'agriculture aux événements climatiques extrêmes dans la Commune de Ouinhi. Mémoire de Master, Département de Géographie et Aménagement du Territoire, UAC.

ISSA M. S. (2012) : Changements climatiques et agrosystèmes dans le Moyen Bénin : impacts et stratégies d'adaptation. Thèse de Doctorat, UAC, 273 p.

LIU H. (2004) : L'utilisation des sols et les dommages causés par les excès d'eau et les inondations dans le bassin moyen du Yangzi. *Géocarrefour*, vol. 79, n° 1, p. 19-26.

MCKEE T. B., DOESKEN N. J. et KLEIST J. (1993) : The relationship of drought frequency and duration to time scales. *Proceedings of the 8th Conference on Applied Climatology*, p. 179-184.

MERTZ O., MBOW C., REENBERG A. et DIOUF A. (2009) : Farmers' perceptions of climate change and agricultural adaptation strategies in rural Sahel. *Environmental Management*, vol. 43, p. 804-816.

OZER P., AFOUDA A., HOUNTONDJI Y.-C. *et al.* (2010) : Effets du réchauffement global sur les variables climatiques au Bénin. *Actes du colloque*, UAC.

VODOUNOU J. B. K. et ONIBON DOUBOGAN Y. (2016) : Agriculture paysanne et stratégies d'adaptation au changement climatique au Nord-Bénin. *Cybergeog* : *European Journal of Geography*, 21 p.

YABI I. (2019) : Changements climatiques et inondations dans la Commune de Ouinhi au Sud-Est du Bénin : pour la transformation de la catastrophe en opportunités. *Espace Géographique et Société Marocaine*.

ZANNOU S. et TCHAOU B. S. (2022) : Aménagement et gestion des infrastructures marchandes dans la Commune de Ouinhi au Bénin. *International Journal of Progressive Sciences and Technologies*.
