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IMPACTS OF CLIMATE CHANGE ON AGRICULTURAL VALUE ADDED IN IVORY COAST

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Purpose. This study assesses the impact of climate change on agricultural value added through temperature and rainfall variability. The study uses annual data for 1992–2022.
Results. The results show that, in the short term, regular rainfall increases agricultural yields and boosts agricultural added value. However, even if temperature changes vary in smaller proportions than rainfall variability, they still lead to production deficits. Over the long term, the study predicts a positive relationship between temperature and agricultural value added. This prediction reveals the positive effects of the implications of economic policies in terms of intelligent agriculture. Over the same period, precipitation has a significant negative value. In fact, the onset of heavy rainfall affects crop productivity and yields, hence its negative impact on agricultural value added.
Scientific novelty. Previous studies on the impact of climate change on agricultural value added have mainly focused on the effects of rainfall and temperature variability on agricultural yields and the share of agricultural value added in the Ivory Coast's GDP. However, very little empirical work has been done on the impacts of climate change on agricultural growth in Ivory Coast. This study fills this gap. It extends the existing literature on the causal relationship between climate change and agricultural development. Finally, the Vector Error Correction Model (VECM) is used to address this issue.
Practical value. The information generated will be useful to a number of organisations, including: research centres, universities, governments, governmental and non-governmental organisations, to better guide the development and implementation of resilience policies and strategies in a context of environmental crisis. Finally, by knowing the existing relationship between climate change and agricultural GDP, as well as the limitations of the resilience policies, the study provides the different ways to improve the capacity for creating agricultural wealth in the climate change issue. Research on this issue is crucial to inform policy makers in developing sustainable economic policies to achieve meaningful agricultural growth in the face of climate crises.
Key words: agricultural added value, climate change, agriculture, Ivory Coast.

Introduction. Climate change is now an established fact that is causing concern among international bodies, expert groups, political decision-makers and ordinary citizens because of the effects it is having on both humans and the planet (Sultan et al., 2017). The effects of climate change are felt everywhere and in many different areas, but are more pronounced in the southern hemisphere for at least two reasons. Firstly, these countries are warmer than the global average and therefore more vulnerable to temperature rises. Secondly, many of these countries are still dependent on agricultural activities, judging by the share of agricultural added value in gross domestic product – GDP (15–20 %) and the share of agricultural employment in total employment (30 %).

In addition to these direct aspects, agriculture in these countries has many links with the non-agricultural sectors: food products, raw materials for the agri-food industry, downstream activities such as product distribution, transport, etc. Conversely, the agricultural sector is a customer of the other sectors, which supply it with the various inputs needed for its production, and acquires agricultural equipment and semi-durable consumer goods from the industrial sector as it modernises (Blanc, 2012).

In the light of these aspects and many others, it is clear how important agriculture is in developing countries. Unfortunately, climate change is having a crucial impact on agricultural yields in these countries, with serious economic and social consequences. On the one hand, such a situation would jeopardise food security in these countries and, above all, would expose a large number of people, if not to hunger, at least to malnutrition, with harmful repercussions for the health of these people and especially their children. On the other hand, a fall in agricultural activity would not only exacerbate poverty, but would also thwart efforts to industrialise, given that priority is given to imports of foodstuffs, the world price of which is steadily rising. As a result, since it is impossible to expand the industrial sector, few jobs are created in it, and those who are forced to leave the countryside can at best only be precarious pseudo workers in various service activities that are not very productive (Baarsch et al., 2020).

Climate change manifests itself in a number of ways: very high temperatures, rainfall that is both erratic and unpredictable, floods, strong winds and droughts. Among the manifestations of climate change, drought is the quietest and least impressive phenomenon, and one that has a huge societal impact (Abidoye & Odusoba, 2015).

Ivory Coast, whose economy is essentially based on the rural sector, could be particularly affected by climate change. Indeed, the performance of this West African country's economy is closely linked to that of the agricultural sector, which in turn depends on the climate (Kouakou, 2024). The climate in Ivory Coast is currently characterised by a significant rainfall deficit, rising temperatures, seasonal variations, strong inter-annual and spatio-temporal irregularity in rainfall and other more extreme and less predictable meteorological phenomena. Current models predict that by 2050, temperatures will have risen by 1 to 4°C and rainfall will be increasingly irregular, with a shift in the start and end of the rainy season according to the World Bank (2023). Obviously, this could affect the stability of agricultural production and export earnings. What's more, according to the same institution, climate change is expected to reduce real GDP by 13 % by 2050, preventing 1.63 million people from escaping poverty.

Hence the importance of knowing the impact of possible climate change on agricultural development.

It is true that several studies have analysed the effects of climate change and its foreseeable impact on agricultural growth in Ivory Coast. However, despite the large number of scientific activities on this subject, no quantitative or empirical study using the VECM method has been carried out on the specific case of Ivory Coast.

The aim of this study is to assess the impact of climate change on agricultural

development in Ivory Coast. Specifically, the aim is to estimate the effects of rainfall and temperature variability on agricultural yields and the share of agricultural value added in the country's GDP.

Review of literature. Several authors have studied the impact of climate change on agricultural production and economic growth. The study by Seo et al. (2009) with a sample of sixteen agro-ecological zones reveals that climate change induces poor agricultural production in dry and humid savannah zones, but better production in humid and sub-humid forest zones. In a similar vein, Schlenker & Lobell (2010) examined the impact of climate change in sub-Saharan Africa. They find that the impacts can be highly variable across space and time, depending on the interactions between rising temperatures and changes in the volume and variability of rainfall.

More recently, on the basis of the "risk triangle" concept, Baarsch et al. (2020) show the vulnerability of African economies to rainfall and temperature fluctuations. They show that inequalities between African countries are likely to increase in a high warming scenario compared with low warming and no warming scenarios.

Reilly et al. (1996) justify this by the fact that as the temperature moves away from the favourable growth temperature for crops, crop growth is affected. Similarly, if temperature variability is high, yields are lower. These authors argue that areas that are too hot or too close to the optimum temperature are likely to be more affected.

Easterling et al. (1993), also using the production function approach, found that climate change in the United States, in the absence of changes in technology or increases in CO_2, could lead to a reduction in production and therefore a source of economic losses.

Studies by Mendelsohn et al. (1994) explored the effect of climate change on the net value of arable land in the USA. Using cross-sectional data at the committee level, they found that higher temperatures throughout the year (except in the autumn season) have a negative effect on average land values.

Molua & Lambi (2007) studied the relationship between climate and farmers' net profit data using a sample of 800 farms in Cameroon. They found that net profit decreases as rainfall decreases and temperature increases.

With this in mind, Lanzafame (2014) looks at the impact of climate change on growth in Africa as measured by temperature and rainfall. Using an ARDL model with a multifactor panel structure and a panel estimator, the obtained results confirm that temperature reduces economic growth. However, rainfall had a weaker effect on growth.

Similarly, Alagidede et al. (2016) studied the relationship between climate change and economic growth in Sub-Saharan Africa. Considering temperature and precipitation data, the authors used panel data cointegration techniques. Their conclusions confirm that temperatures above 24.9°C inhibit economic growth in Sub-Saharan Africa.

Saleem et al. (2024) reveal that the detrimental effects of diverse climate change are concerning with regard to the developing nations where agriculture performs an

essential part in assuring both economic growth and food security.

The study by Abbas (2022) show that the significant temperature variations induced by climate change directly influence the crop productivity. Increasing temperatures lead to heightened levels of heat and water-related pressures, which lowers agricultural output.

According to Elahi et al. (2022), increasing temperatures have impacted agricultural productivity through multiple processes, including increased water stress, changed crop phenology, and increased pest and disease pressure. Moreover, heat stress can reduce crop yields, degrade crop quality, and interfere with pollination at crucial growth phases.

Finally, the study by Tesfaye et al. (2017) reported that decreased maize and teff yields in Ethiopia resulted from increased rainfall variability. In fact, the drastic changes in precipitation patterns can cause infrastructure damage and agricultural loss. Droughts have caused a decrease in agricultural productivity and food security while unusual rainfalls have deteriorated the ripe crops.

Materials and methods. The model used is based on a production function approach that relates agricultural value added (*Y*) to capital (*K*), the export price of agricultural products (*Px*), agricultural yield (*Ay*) and the climate change indicator (*CC*). The model is close to the one used by Bsais & Mkaddem (2019), which is specified as follows:

$$Y_t = F(K_t, Px_t, Ay_t) = e^{\delta.cc} \cdot Px_t^{\alpha} \cdot K_t^{\beta} \cdot Ay_t^{\theta} \quad (1)$$

with

$$\theta_A = \lambda_0 \cdot CC. \quad (2)$$

Substituting (2) into (1), equation (3) is expressed in terms of growth rate and is written as follows:

$$\frac{\Delta Y_t}{Y_t} = \alpha \frac{\Delta Px_t}{Px_t} + \beta \frac{\Delta K_t}{K_t} + \delta CC + \lambda_0 \frac{\Delta Ay_t}{Ay_t} + \lambda_1 \frac{\Delta Ay_t}{Ay_t} \cdot CC. \quad (3)$$

In this study, the variables precipitation (P) and temperature (T) were used as indicators of climate change. Thus, the model expressed in log is written as follows:

$$LogY_t = C + \alpha_0 LogPx_t + \beta_0 LogK_t + \delta_0 LogP + \lambda_0 LogAy_t + \lambda_1 LogT + \varepsilon_t, \quad (4)$$

where: *Y* – the agricultural value added achieved by Ivory Coast;

Px – the export price of agricultural products;

K – accumulation of human, technical and financial capital;

Ay – agricultural yield;

P – precipitation;

T – temperature;

ε_t – term of error;

δ_0 *et* λ_1 measure the direct effect of climate change on agricultural value added.

The data used in this study come from the World Bank and the National Statistics Institute (NSI). They are annual and cover the period 1992–2022. This study period was chosen in order to avoid series with missing data. In addition, the series proposed by these institutions make it possible to carry out estimates over a fairly long period,

thus enabling sufficiently robust results to be obtained. These data concern variables such as the share of agricultural value added in gross domestic product (*Y*), the export price of agricultural products (*Px*), capital (*K*), agricultural yield (*Ay*), precipitation (*P*) and temperature (*T*).

Table 1

Description of used variables

Variables	Descriptions	Expected effects
Y	Agricultural value added, USD	+
Px	Export prices for agricultural products, USD	+
K	Capital, CFA francs	+
Ay	Agricultural yield, kg/ha	+
P	Precipitation, mm	+
T	Temperature, degrees Celsius	+

Source: author's research based on theory.

Results and discussion. *Relationship between agricultural value added and the climate variables.* Figure 1 and 2 show a figurative rise in agricultural value added from 1980 to 1994, reaching around 35 % of GDP. From 1994 to 1998, agricultural value added declined as a result of the fall in world cocoa prices. From 1998 to the present day, there has been a period of stability, despite a few disturbances. Over the same period, the temperature has remained more or less stable, despite slight variations (Figure 1). Between 1980 and 1986, rainfall fell before stabilising from 1990 until 1997. From 1997 to 1998, precipitation decreased again. The period from 1998 to the present day has seen apparent stability, with average annual rainfall of around 1,000 mm (Figure 2).

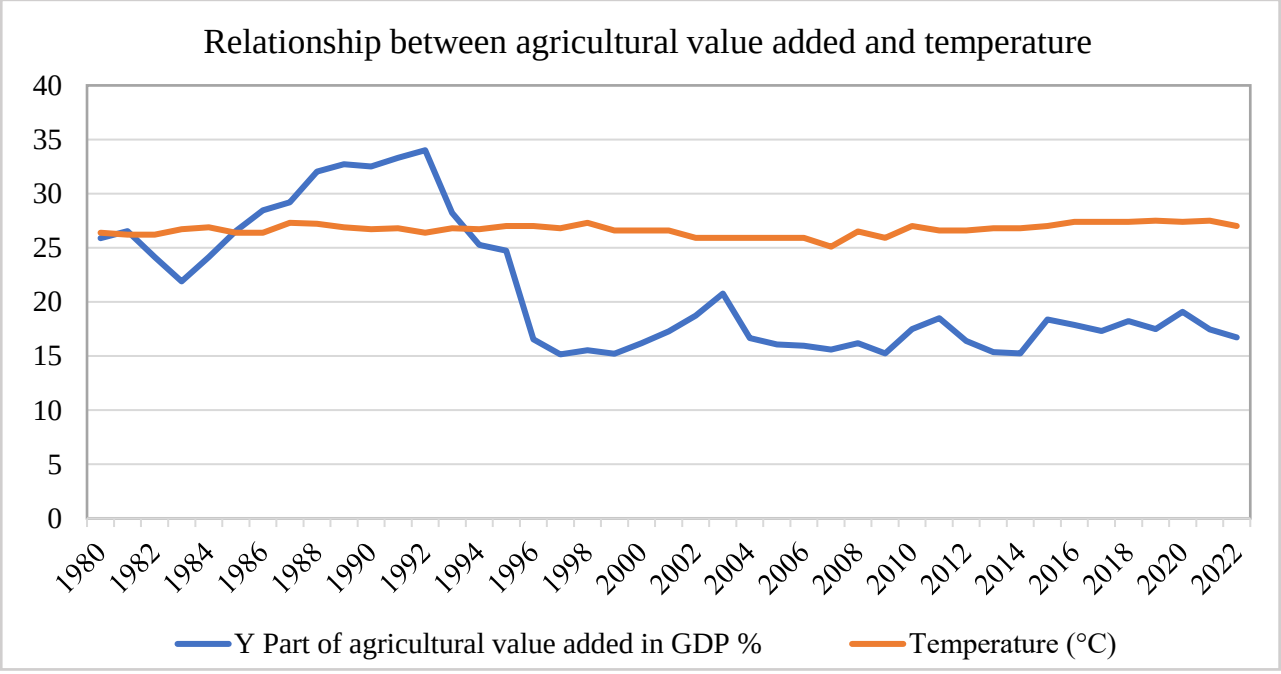

Figure 1. Evolution of agricultural value added and temperature over the period 1980–2022

Source: author's estimation using Eviews.

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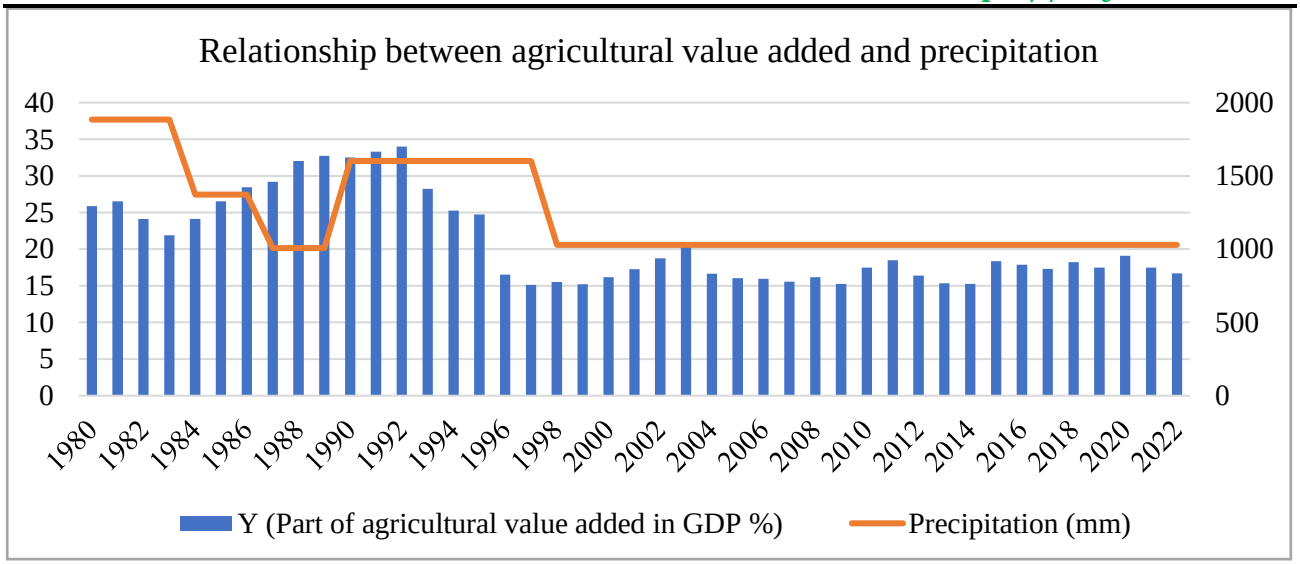

Figure 2. Evolution of agricultural value added and precipitation over the period 1980–2022

Source: author's estimation using Eviews.

Stationarity test (ADF unit root test). According to Table 2, all the variables (LOGPIB, LOGK, LOGPx, LOG P, LOGAy, LOGT) and the probabilities of the ADF statistics are below the various thresholds, after first differentiation. They are therefore integrated of order one (I(1)). There is then a cointegration relationship.

Table 2

Application of the ADF unit root test

Level		First difference	Decision
LOG(Y) (0.9998)	1.5390	-8.8916 (0.000)	I (1)
LOG(K) (0.684)	-1.3780	-9.3123 (0.000)	I (1)
LOG(Px) (0.9852)	0.5431	-3.3631 (0.021)	I (1)
LOG(P) (0.6093)	-1.3115	-16.898 (0.0001)	I (1)
LOG(Ay) (0.0806)	-2.7530	-3.2521 (0.390)	I(1)
LOG(T) (0.5309)	-1.4740	-12.9089 (0.000)	I(1)

Source: author's research based on Eviews 10.

Determination the optimum number of delays. According to Table 3, the optimal VAR is of order 2, i.e. a VAR (2) following the estimation of the functions AIC(P) and SC(P).

Table 3

Determination of the optimal number of delays

Number of delays	Akaike criteria	Schwarz criteria
P = 1	153.2815	154.9889
P = 2	150.2380	153.6328

Source: author's research based on Eviews 10.

Johansen cointegration test (Trace test). The obtained results using the maximum likelihood method (Table 4) show that the probabilities of the trace statistic are below the 5 % threshold "at level" and "at most 1". The $_{H0}$ hypothesis is rejected. There are two cointegration relationships. The error correction model can therefore be retained.

Table 4

Johansen cointegration test (trace test)

Indicators	Statistical trace	Probability
At level*	195.4472	0.0000
More 1*	86.0769	0.0015
More 2	45.4801	0.0822
More 3	16.4335	0.6815
More 4	7.1159	0.5642

Note. * indicate the indicator selected for the results.

Source: author's research based on Eviews 10.

Diagnostic or residual tests. Normality test. The Jarque-Bera normality test shows that the residuals are Gaussian white noise (normal) because the Jarque-Bera statistics are all below 5.99 (Table 5). The hypothesis that the residuals are normal is therefore accepted.

Table 5

Normality test

Component	Jarque-Berra	dl	Probability
1	25.3670	2	0.0000
2	207.6989	2	0.0000
3	1.1425	2	0.5648
4	2.4314	2	0.2965
5	0.8465	2	0.6549
6	0.3752	2	0.8289

Source: author's research based on Eviews 10.

Residual heteroscedasticity test (White's test). In this study, the probability of making an error is greater than $\alpha = 5$ % (Table 6). The hypothesis of homoscedasticity is therefore accepted. Moreover, $p = 0.2685 > \alpha = 0.05$, the estimates obtained are optimal.

Table 6

White's test

Chi-sq	df	Probability
565	546	0.2685

Source: author's research based on Eviews 10.

Error autocorrelation test. According to the results reported in Table 7, the LM test for serial independence of random deviations shows that the errors are independent, since the probability of making a first order error is greater than 5 %. Furthermore, the model is well specified. There is no autocorrelation and the errors are homoscedastic. The model is also structurally and cyclically stable. The econometric robustness of the model is therefore satisfactory and the explanatory power of each equation is high.

Table 7

Error autocorrelation test

Lags	LM-Stat	Probability
1	0.901595	0.6170
2	1.032563	0.4923
3	2.289158	0.0396
4	2.454244	0.0289
5	1.076580	0.4540
6	3.340734	0.0062
7	1.340734	0.2694
8	0.767979	0.7514
9	0.734529	0.7840
10	1.090165	0.4425

Source: author's research based on Eviews 10.

VECM model: Short- and long-term relationship between agricultural value added (Y) and exogenous variables (K, Px, Ay, P, T). The results shown in Tables 8 and 9 suggest that, in the short term, capital accumulation (*K*), rainfall variability (*P*) and agricultural yield (*Ay*) have positive and significant effects on agricultural growth. Massive investment in the agricultural sector improves agricultural productivity and therefore agricultural development. Kouakou (2022) supports this assertion. Moreover, in Ivory Coast, farmers are closely dependent on rain-fed agriculture, which accounts for almost 93 % of cultivated land. Thus, regular rainfall increases agricultural yields and stimulates an increase in agricultural value added. Conversely, there is a significant negative relationship between temperature and short-term agricultural growth. Even if temperature changes vary in smaller proportions than rainfall variability, they lead to production deficits.

Table 8

VECM short-term model

Variables	Coefficients	Statistics
LOG(K)	0.245	1.798*
LOG(Px)	6.950	0.432
LOG(P)	1.298	0.755*
LOG(Ay)	1,319	1.939*
LOG(T)	-0.469	-1.693*
Ec	-0.456	-2.337

Table 9

VECM long-term model

Variables	Coefficients	Statistics
LOG(K)	- 0.598	-1.135
LOG(Px)	-4.490	-1.891*
LOG(P)	-81.830	-9.697***
LOG(Ay)	-6.678	-1.941*
LOG(T)	9.829	9.532***
R^2	0.5262	

Note. *, ** and *** indicate significance at the 1 %, 5 % and 10 % thresholds respectively.
Source: author's research based on Eviews 10.

In fact, temperature variability causes heat stress, affecting the productivity of those involved in agriculture and reducing crop yields. Furthermore, this increase in temperature leads to drought, the appearance of new diseases, crop losses and a drop in yields with the risk of fire. In addition, when the temperature moves away from the growth temperature favourable to crops, crop growth is affected. This justifies the negative link between this variable and agricultural development. Several sources confirm these assertions: Dandonougbo (2020), Barrios et al. (2008), Schlenker & Lobell (2010), Sultan et al. (2017), Marega & Maring (2018) and Sultan et al. (2015).

Furthermore, the export price of agricultural products does not influence agricultural development in the short term. According to economic theory, in the short term, agricultural production is generally inelastic, i.e. the elasticity with respect to the price of agricultural products is low. This justifies the lack of correlation between this variable and growth in agricultural value added over the same period.

Over the long term, the study predicts a positive relationship between temperature (*T*) and agricultural value added. This prediction reveals the positive effects of the implications of economic policies in terms of intelligent agriculture, an agriculture that increases the productivity and resilience (adaptation) of crops in a sustainable manner. Terjung et al. (1984) and Sultan et al. (2015) support this assertion. Moreover, over the same period, variables such as rainfall (*P*), the export price of agricultural products (*Px*) and agricultural yield have negative and significant values. The erratic pattern and timing of heavy rainfall cause flooding and run-off, leading to soil erosion, nutrient depletion and loss of topsoil. This situation affects the use of capital goods and land, and consequently productivity, by affecting crop yields, hence its negative impact on growth in agricultural value added. The World Bank (2023) confirms these results.

World prices for agricultural products are reflected in domestic prices, with producers in developing countries acting as price takers rather than price setters. These price levels do not take into account production and operating costs, or even the cost of climate change resilience measures (mitigation and adaptation actions). Therefore, in the absence of measures to support agricultural production and prices, high production costs affect farmers' incomes and have a negative impact on productivity, agricultural yields and therefore agricultural value added. Dandonougbo (2020) obtained the same results in his study on the effect of temperature and rainfall variability on the net income from cereal crops in Togo.

The variable *K* (Capital) also has a negative but insignificant effect on long-term agricultural development. The inefficiency of resilient public investments explains the weak influence of capital (*K*) on long-term agricultural development. The World Bank (2023) in its national report on climate and development in Ivory Coast endorses these results.

Conclusions. Climate change is one of the most serious concerns of the 21st century because of its close correlation with the economies of developing countries. The aim of this study was to assess the impact of rainfall and temperature variability on agricultural growth in Ivory Coast. The model used is based on a production

function approach that relates agricultural value added to capital, the export price of agricultural products, agricultural yield and the climate change indicator. The study uses stationarity tests and Vector Error Correction Model.

The results of the assessment showed that, in the short term, rainfall variability has a positive and significant effect on agricultural development. Conversely, there is a negative and significant relationship between temperature and agricultural growth. Regular rainfall increases agricultural yields and stimulates an increase in agricultural added value. However, even if temperature changes vary in smaller proportions than rainfall variability, they still lead to production deficits.

Over the long term, the study predicts a positive relationship between temperature and agricultural value added. This prediction reveals the positive effects of the implications of economic policies in terms of intelligent agriculture, an agriculture that increases the productivity and resilience (adaptation) of crops in a sustainable manner. In contrast, over the same period, rainfall recorded a significant negative value. The irregularity and timing of heavy rains cause flooding and run-off, leading to soil erosion, nutrient depletion and loss of topsoil. This situation affects the use of capital goods and land, and consequently productivity, by affecting crop yields, hence its negative impact on growth in agricultural added value.

Based on the results, recommendations are made:

- adopt adaptation strategies;
- adopt a combination of actions including the implementation of conservation agriculture and the transition to cover cropping;
- develop new irrigation infrastructures to combat water stress;
- produce crops that are resistant to climate change;
- increase the proportion of heat-tolerant crop varieties;
- finally, accelerate climate-smart financing to reduce future climate impact.

This paper analyses the effect of climate change on the agricultural sector as a whole. This does not allow us to assess the specific effect of climate change on each agricultural sub-sector. In future research, the effect of climate change on different agricultural sectors will be specifically studied in order to develop a resilient agricultural policy.

References

1. Abbas, S. (2022). Climate change and major crop production: evidence from Pakistan. *Environmental Science and Pollution Research*, 29(4), 5406–5414. https://doi.org/10.1007/s11356-021-16041-4.

2. Abidoye, B., & Odusoba, A (2015). Climate change and economic growth in Africa: an econometric analysis. *Journal of African Economies*, 24(2), 277–301. https://doi.org/10.1093/jae/eju033.

3. Alagidede, P., Adu, G., & Frimpong, P. B. (2016). The effect of climate change on economic growth: evidence from Sub-Saharan Africa. *Environmental Economics and Policy Studies*, 18, 417–436. https://doi.org/10.1007/s10018-015-0116-3.

4. Baarsch, F., Granadillos, J. R., Hare, W., Knaus, M., & Krapp, M. M.,

Schaeffer, M., & Lotze-Campen, H. (2020). The impact of climate change on income and convergence in Africa. *World Development*, 126, 104699. https://doi.org/10.1016/j.worlddev.2019.104699.

5. Bsais, A., & Mokaddem, L. (2019). The impact of climate change on agriculture and economic growth in Tunisia. University Publication Centre University Campus of Tunisia. Available at: https://www.researchgate.net/publication/330967827.

6. Barrios, S., Ouattara, B., & Strobl, E. (2008). The impact of climatic change on agricultural production: is it different for Africa? Available at: https://mpra.ub.uni-muenchen.de/6240/1/MPRA_paper_6240.pdf.

7. Blanc, E. (2012). The impact of climate change on crop yields in the Sub-Saharan Africa. *American Journal of Climate Change*, 1(1), 1–13. https://doi.org/10.4236/ajcc.2012.11001.

8. Dandonougbo, Y. (2021). Effect of temperature and precipitation variability on net income of cereal crops in Togo: semi-parametric approach. *Research Paper 435*. African Economic Research Consortium. Available at: https://publication.aercafricalibrary.org/server/api/core/bitstreams/df0acfa5-8fb2-4e4a-97e8-194ead2e9121/content.

9. Easterling, W. E., Crosson, P. R., Rosenberg, N. J. Mc Kenney, M. S., Katz, L. A. & Lemon, K. M. (1993). Paper 2. Agricultural impacts of and responses to climate change in the Missouri-IowaNebraska-Kansas (MINK) region. *Climatic Change*, 24, 23–61. https://doi.org/10.1007/BF01091476.

10. Elahi, E, Khalid, Z, Tauni, M. Z., Zhang, H., & Lirong, X. (2022). Extreme weather events risk to crop-production and the adaptation of innovative management strategies to mitigate the risk: a retrospective survey of rural Punjab, Pakistan. *Technovation*, 117, 102255. https://doi.org/10.1016/j.technovation.2021.102255.

11. Kouakou, P.-A. K. (2022). Public investment, agricultural development and economic growth in Ivory Coast: causal links according to the econometric approach. *Moroccan Journal of Agricultural and Veterinary Sciences*, 10(4), 497–502. Available at: https://www.agrimaroc.org/index.php/Actes_IAVH2/article/view/1293/1738.

12. Kouakou, P.-A. K. (2023). Impact of local processing of agricultural raw materials on job creation in the West African Monetary and Economic Union. *Agricultural and Resource Economics*, 9(3), 250–265. https://doi.org/10.51599/are.2023.09.03.11.

13. Lanzafame, M. (2014). Temperature, rainfall and economic growth in Africa. *Empirical Economics*, 46(1), 1–18. https://doi.org/10.1007/s00181-012-0664-3.

14. Marega, O., & Mering, C. (2018) Sahelian agropastoralists facing socio-environmental changes: new issues, new risks, new transhumance axes. *Geographical Space*, 47(3), 235–260. https://doi.org/10.3917/eg.473.0235.

15. Mendelsohn, R. (2008). The impact of climate change on agriculture in developing countries. *Journal of Natural Resources Policy Research*, 1(1), 5–19. https://doi.org/10.1080/19390450802495882.

16. Molua, E. L., & Lambi, C. M. (2007). The economic impact of climate change on agriculture in Cameroon. *CEEPA Discussion Paper No. 17*. Special Series on Climate Change and Agriculture in Africa. Available at: https://www.researchgate.net/publication/23550362.

17. Reilly, J., Baethgen, W. E., Chege, F. E., & Van de Vijver, C. A. D. M. (1996). Agriculture in a changing climate: impacts and adaptations. In R. T. Watson, M. C. Zinyowera, R. H. Moss (Eds.), *Climate Change 1995: Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analyses* (pp. 427–468). Cambridge, Cambridge University Press. Available at: https://www.researchgate.net/publication/40146147.

18. Saleem, A., Anwar, S., & Nawaz, T., Fahad, S., Saud, S., Ur Rahman, T., Rasheed Khan, M. N., & Nawaz, T. (2024). Securing a sustainable future: the climate change threat to agriculture, food security, and sustainable development goals. *Journal of Umm Al-Qura University for Applied Sciences*, 2024. https://doi.org/10.1007/s43994-024-00177-3.

19. Sultan, B., Lalou, R., Amadou Sanni, M., Oumarou, A., & Soumaré, M. A. (Ed.) (2017). *Rural societies facing climate and environmental change in West Africa*. IRD Éditions. Available at: https://horizon.documentation.ird.fr/exl-doc/pleins_textes/divers19-05/010074961.pdf.

20. Sultan, B., Roudier, P., & Traoré, S. (2015). The impact of climate change on agricultural yields. In B. Sultan, R. Lalou, M. Amadou Sanni, A. Oumarou, M. A. Soumaré (Eds.), *Les sociétés rurales face aux changements climatiques et environnementaux en Afrique de l'Ouest (1-)* (pp. 209–225). IRD Éditions. https://doi.org/10.4000/books.irdeditions.9773.

21. Schlenker, W., & Lobell, D. B. (2010). Robust negative impacts of climate change on African agriculture. *Environmental Research Letters*, 5, 014010. https://doi.org/10.1088/1748-9326/5/1/014010.

22. Seo, S. N., Mendelsohn, R., Dinar, A., Hassan, R., & Kurukulasuriya, P. (2008). A Ricardian analysis of the distribution of climate change impacts on agriculture across agro-ecological zones in Africa. *Environmental and Resource Economics*, 43, 313–332. https://doi.org/10.1007/s10640-009-9270-z.

23. Tesfaye, K., Zaidi, P. H., Gbegbelegbe, S., Boeber, C., Rahut, D. B., Getaneh, F., Seetharam, K., … & Stirling, C. (2017). Climate change impacts and potential benefits of heat-tolerant maize in South Asia. *Theoretical and Applied Climatology*, 130, 959–970. https://doi.org/10.1007/s00704-016-1931-6.

24. World Bank (2023). *Côte d'Ivoire Country Climate and Development Report*. Washington, DC, World Bank. Available at: https://openknowledge.worldbank.org/handle/10986/40560.