

The Effect of Climate Change on Monetary Stability in Algeria: A Wavelet Analysis for the period (1996-2021)

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Abstract: *The purpose of this research paper is to investigate the relationship between climate change and monetary stability, which is the primary goal of the Bank of Algeria's monetary policy by employing wavelet analysis on monthly data over the period 1996 to 2021 . The results showed that temperature changes affect inflation in the short run, while rainfall affects food inflation in the short and long run. These findings highlight the importance that Bank of Algeria must place on climate change in the designing and management of monetary policy, as well as coordinating with the government to mitigate the effects of these changes on macroeconomic indicators and banking system institutions, allowing them to finance economic agents more effectively.*

Keywords: Climate Change; Monetary Policy; Inflation; Wavelet Coherency Analysis.

JEL Classification: C49; E31; E52; Q54.

ملخص : تهدف هذه الورقة البحثية إلى التحقق من العلاقة بين التغيرات المناخية والإستقرار النقدي الذي يمثل الهدف الرئيسي للسياسة النقدية لبنك الجزائر بإستخدام منهجية التحليل المويجي لبيانات شهرية تغطي الفترة من 1996 إلى 2021. توصلت نتائج الدراسة إلى أن تقلبات درجة الحرارة تؤثر في المدى القصير على التضخم، بينما يؤثر تساقط الأمطار على تضخم المواد الغذائية في المدى القصير والطويل. تعكس هذه النتائج الأهمية التي يجب أن يوليها بنك الجزائر للتغيرات المناخية في تصميم وإدارة السياسة النقدية، وضرورة التنسيق مع الحكومة للتخفيف من حدة هذه التغيرات على المؤشرات الإقتصادية الكلية وعلى مؤسسات النظام المصرفي بما يسمح لها بتمويل الأعوان الإقتصاديين بفعالية.

الكلمات المفتاحية : التغير المناخي، السياسة النقدية، التضخم، تحليل التماسك المويجي.

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1.Introduction

Climate change is one of the most pressing issues confronting current and future generations of humanity. Nowadays, the world is required to reduce greenhouse gases, which are causing unprecedented high temperatures and a change in rainfall patterns, as some areas are threatened by drought, while others are threatened by floods. Therefore, pollution has increased by 150% since the industrial revolution.

The implications of climate change have a strong impact on economic activity. Besides, it is recognized to be one of the most important sources of risk. So, the world's central banks must consider these changes when designing and managing their monetary policies.

The African Development Bank (ADB) points out that Africa loses about 15% per capita GDP annually due to climate change, although the continent's contribution to global emissions does not exceed 3%.

Algeria is one of the African countries most vulnerable to the threat of climate change due to a variety of factors related to its geographical location and large land area; these changes are primarily manifested in a significant rise in temperatures and a continuous decrease in rainfall. These factors have a particular impact on the agricultural sector's output and market prices. Since these products make up the majority of the consumer basket, it is necessary to consider the impact of climate change on the Bank of Algeria's monetary policy in achieving the goal of price stability.

In light of the foregoing, the following research question can be raised:

Do changes in climatic conditions affect price stability which is the principal goal of the Bank of Algeria's monetary policy?

2. Causes of climate change

Climate is one of the most important elements of the natural environment represents the long-term weather condition in a specific location, whereas climate changes are those changes recorded in the characteristics of one or more elements of the climate. These elements are manifested in the rise of the earth's temperature directly related to the increasing phenomenon of global warming, erosion of ice caps that contribute to the rise in sea level, abnormal precipitation conditions, change in snowfall and impact large areas of land by desertification and drought. Consequently, we distinguish between natural and anthropogenic causes of climate change and global warming (Benkacir & Boumendjel, 2022, pp. 64-65):

2.1. Natural causes: The tectonic processes referred by the theory of continental displacement, volcanic eruptions that contribute to carbon emissions, astronomical changes and the phenomenon of sunspots caused by a disturbance in the sun's magnetic field leads to an increase in thermal radiation.

2.2. Anthropogenic causes: It has become the primary cause of climate change and it is attributed to human intervention and mismanagement of natural resources such as the increased use of fossil fuels, industrial activities that are polluting the environment, particularly in the developed countries, urban expansion by destroying green spaces and forests, the increased use of chemicals, pesticides and an increase in gases emitted from sewage.

3. Climate Change and Monetary Policy

The extent to which the Central Bank achieves its ultimate goals of achieving price stability as well as stimulating economic growth and employment depends on a variety of factors, the majority of which are related to the structure of the domestic economy and the nature of internal and external shocks to which it may be exposed.

Climate change is one of the most significant factors influencing economic activity and price stability. Agriculture is regarded as one of the most important economic sectors affected by climate change, so the improvement of agricultural production and livestock is linked to the fall of sufficient amounts of rain and appropriate temperatures.

According to (Breitenfellner & Pointner, 2021) climate change affects price stability and the mechanism of monetary policy transmission to economic activity. It also contributes to creating instability in credit markets due to an increase in the probability of default and the numbers of nonperforming loans which exposes commercial banks' assets to risks and thus negatively affects the credit channel's role.

(Schnabel, 2021, p. 54) suggests that climate change affects price stability through at least three channels:

First, the effects of climate change may impair the transmission of central banks' monetary policy measures to the financing conditions faced by households and firms and thus to consumption and investment. Losses from materializing physical risks or stranded assets (such as oil reserves that will not be tapped as the world transitions away from fossil fuels) could put a strain on financial institutions balance sheets, reducing credit flow to the real economy. Furthermore, the longer climate change is ignored, the greater risks to policy transmission from a sharp and abrupt increase in credit risk premiums. Central banks face potential losses from securities acquired through asset purchase programs as well as collateral provided by counterparties in monetary policy operations.

Second, climate change may reduce the space for traditional monetary policy by lowering the equilibrium real rate of interest, which balances savings and investment. To illustrate, higher temperatures might impair labor productivity or increase rates of morbidity and mortality. Climate-related uncertainty may increase precautionary savings and reduce incentives for the investment, while productive resources may be reallocated to support adaptation measures. These factors, taken together can lower the real equilibrium interest rate, increasing the likelihood that a central bank's policy rate will be constrained. However, this is far from certain equilibrium rates that could rise as a result of green innovation and investment, paving the way out to the current low-inflation and low-interest-rate environment.

Third, both climate change and mitigation policies can have an immediate impact on inflation dynamics. Recent history demonstrates that a higher incidence of physical risk can cause short-term fluctuations in output and inflation, which amplify longer-term macroeconomic volatility.

Unless mitigation policies are strengthened, the risk of even larger climate shocks increases, with more long-term implications for prices and wages. Furthermore, mitigation policies, such as carbon pricing programs can have an impact on price stability, potentially causing large and long-lasting trends in relative prices and driving a wedge between headline and core inflation measures.

Climate change increases also the risks of the industrial sector by affecting energy prices and the infrastructure of production structures, such as floods or high temperatures that cause fires, resulting in the transfer of important amounts of money to repairs and refurbishments rather than utilizing them for promoting investment, developing production chains and encouraging innovation.

Climate change and climate policies have an impact on the structure and dynamics of the economy and the financial system by posing risks to price stability and financial stability, these risks have evolved from their traditional form, where their effects are material as a result of natural disasters to the risks of shifting to a carbon-neutral economy and its ramifications for industrial production enterprises, thus directly affecting the monetary policy objectives of central bank (Boneva, Ferrucci, & Mongelli, 2022, p. 2). Using a stock-flow-fund ecological macroeconomic model, (Dafermos, Nikolaidi, & Galanis, 2018) examined the effects of climate change on financial stability and the financial and global warming implications of a green quantitative easing (QE) programme. Emphasis is placed on the impact of climate change damages on the price of financial assets and the financial position of firms and banks. They found four key results:

First, by destroying the capital of firms and reducing their profitability, climate change is likely to gradually deteriorate the liquidity of firms, leading to a higher rate of default that could harm both financial and non-financial corporate sector.

Second, climate change damages can lead to a portfolio reallocation that can cause a gradual decline in the price of corporate bonds.

Third, climate-induced financial instability might adversely affect credit expansion, exacerbating the negative impact of climate change on economic activity.

Fourth, the implementation of a green corporate QE programme can reduce climate-induced financial instability and restrict global warming.

In addition, climate change increases uncertainty, necessitating the strengthening of precautionary measures and banking supervision in order to serve the goal of stability. As a result (McKibbin, Morris, Wilcoxon, & Panton, 2020) affirm that central banks are more obligated than ever to adapt their monetary policy to climate change and that they must work on developing models that will allow them to anticipate and respond to rising inflation and slowing economic growth as a result of climate policy change.

Green monetary policy has become the focus of central banks today, as central banks support the banking system's institutions to inject the necessary funds to accelerate the transition to reduce carbon dioxide emissions from economic activity and mobilize more capital for green investment in accordance with the Paris Agreement on climate (2015) COP 21 (Vestergaard, 2022, p. 4).

4. Empirical Evidence

A number of previous studies suggest that climate change may have a significant impact on macroeconomic variables including inflation. In one of the most important contributions (Burke, Hsiang, & Miguel, 2015) estimated the overall nonlinear effect of temperature changes on economic productivity in 166 developed and developing countries over the period (1960-2010). According to the study's findings, the average annual optimum temperature of 13°C contributes to high levels of productivity, while rising temperature reduce economic output, and the accumulated global loss of income due to climate change is projected to be 23% by 2100.

(Mukherjee & Ouattara, 2021) investigated the relationship between climate change and monetary policy by examining the effect of temperature shocks on inflation using an Panel VAR model from a group of developed and developing countries over the period (1961-2014). The results revealed that increasing temperatures leads to higher inflation. These are the same results as (Faacia, Parker, & Stracca, 2021) in analyzing the effect of temperature rise on the stability of various prices represented in consumer prices for food and non-food items and producer prices over 48 countries for the period (1990-2018). (Yuan, Cui, Wang, & Xu, 2022) conducted a study on 131 Chinese provinces from 1991 to 2018 and showed that high temperatures had a negative effect on agricultural production growth which will increase food prices.

(Kunawotor, 2022) estimated the impact of extreme weather events on inflation and its implications on monetary policy in 52 African countries, including Algeria, using a two-step dynamic system GMM (Generalized Method of Moments) estimation strategy with robust standard errors for the period (1990-2017). The findings showed that extreme changes in the weather condition lead to a significant increase in prices. Moreover, the periods of drought or floods greatly affect food inflation.

Using quantitative-panel estimation techniques to analyze the relationship between climate change and food prices in 8 countries in eastern and southern African countries for the period (2001-2020), (Odongo, Misati, Kamau, & Kisingu, 2022) found a positive and significant effect of rainfall variability on food inflation and overall inflation, while temperature variability positively affect inflation and its impact extends to other components included in the consumer basket, such as electricity prices.

Recently, (Cevik & Jalles, 2023) investigated the impact of climate change on inflation and real GDP using local projection method on 173 countries over the period (1970-2020) and found that Consumer price inflation respond significantly to climate shocks and the impact depends on the state of economy and income level.

On their side, (Kotz, Kuik, Lis, & Nickel, 2023) Applied fixed-effects panel regression models to identify the impact of change in climate variables on national level inflation rates on 121 countries from 1991 to 2020 and found that temperature shocks result in non-linear upwards inflationary pressures which persist over 12 months in developing and developed countries.

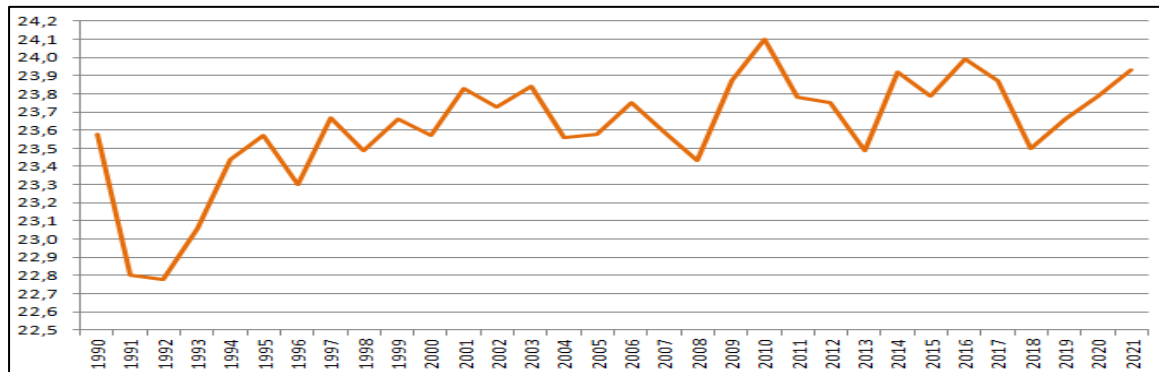
5. Evolution of temperature, rainfall and inflation in Algeria

Algeria is Africa's largest country, with a land area of approximately 2.381.741 km² and an important location on the Mediterranean Sea's shores. Algeria's climate is divided into three major types: the Mediterranean climate which covers the area opposite the coast and is characterized by rainy and mild winters, while the summer is hot and dry. Whereas, the continental climate, also known as the semi-arid climate which is characterized by low rainfall and high temperatures in the interior regions and high plateaus. However, the desert climate which is characterized by a lack of rainfall and a significant rise in temperature across the majority of Algeria.

5.1. Temperature

Temperature is the most important climatic factor influencing agricultural production, as agricultural crops are determined by the maximum and minimum temperature values suitable for plant growth in their biometric environment.

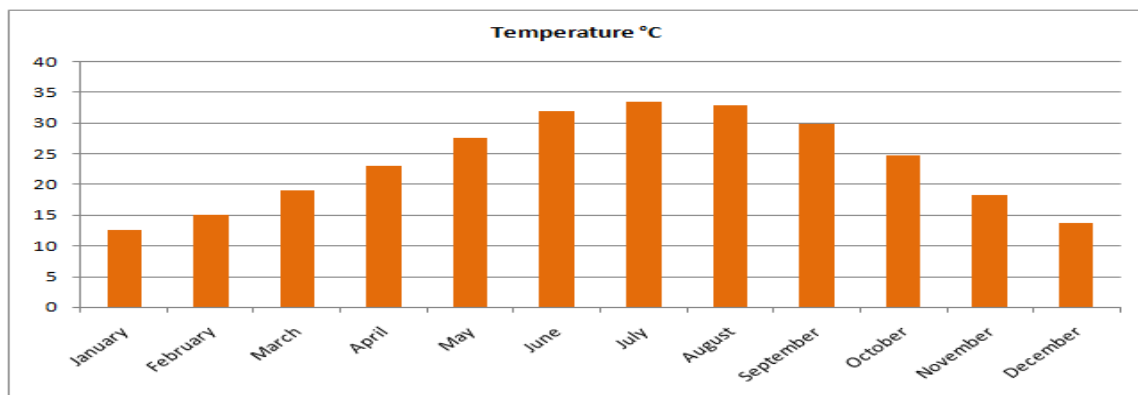
Figure (1) depicts the fluctuation of Algeria's average annual temperature in degrees Celsius from 1990 to 2021, with a continuous rise in temperature reaching a peak of 24.1°C in 2010.



Source: Prepared by researchers based on Climate Knowledge Portal of the World Bank

Figure (1): Average annual temperature in Algeria for the period (1990-2021)

The temperature rises as we move away from the coastline opposite the Mediterranean Sea, and the hot southern winds contribute to the extremely high temperatures in southern Algeria, as shown by the temporal distribution of the temperature. During the entire period (1991-2020), the state of Adrar in the Algerian desert has the highest average maximum temperature of about 44°C compared to 24°C in winter, while the state of Oum El Bouaghi in the east of Algeria has the lowest average temperature level of about 25°C in summer compared to 6.5°C in winter.



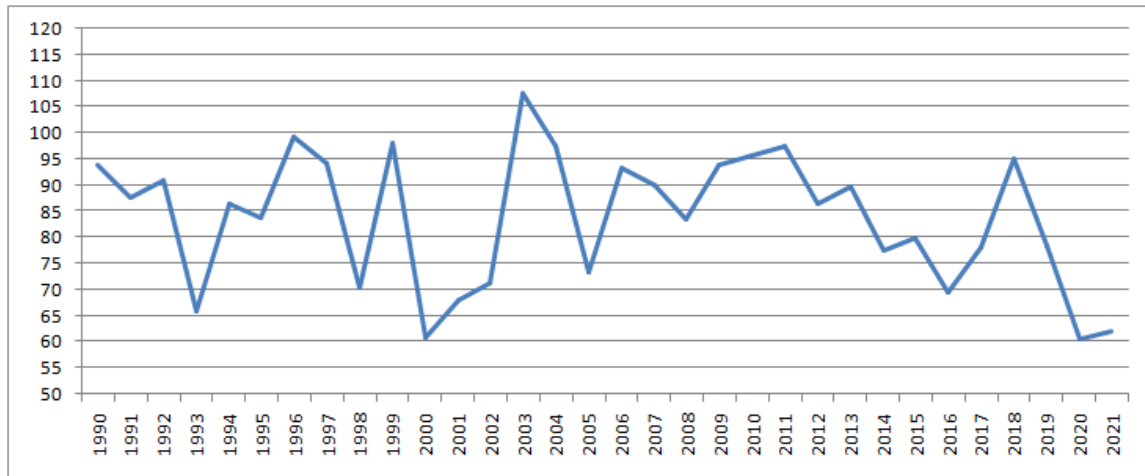
Source: Prepared by researchers based on Climate Knowledge Portal of the World Bank

Figure (2): Monthly mean temperature in Algeria for the period (1991-2020)

5.2. Rainfall

Rainfall has a direct impact on agricultural production. The precipitation amounts vary across the country, with western and northwestern winds assisting rainfall in northern Algeria while decreasing rainfall in the high plateaus and desert areas in the south of this country. Figure (3) depicts the annual average rainfall in Algeria from 1990 to 2021, with a downward trend from 107.6 mm in 2003 to 62 mm in 2021, except for a 95 mm increase in 2018, which negatively affected the percentage of filling water dams (about 80 dams in 2021 with a capacity of 8.3 billion cubic meters) and pushed public

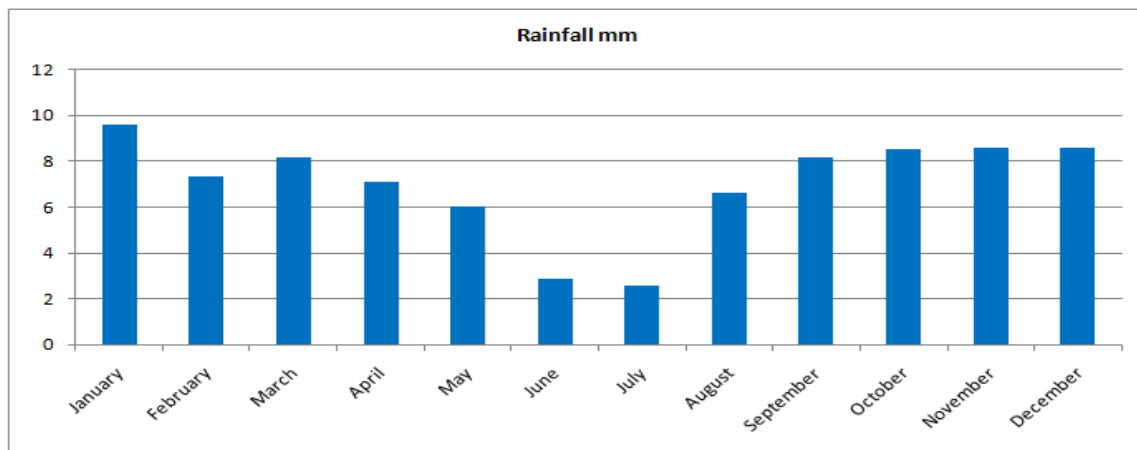
authorities to adopt the seawater desalination despite its high costs (Algeria has 11 plants with a production capacity of 760 million cubic meters per year).



Source: Prepared by researchers based on Climate Knowledge Portal of the World Bank

Figure (3): Average annual rainfall in Algeria for the period (1990-2021)

The annual distribution of rainfall in Algeria shows an increase in the percentage of precipitation in the winter and autumn seasons, while it is very weak in the summer. During the period (1991-2020), the state of El Taref (east of Algeria) recorded the highest rate of precipitation with about 239 mm in winter and 209 mm in spring, in contrast to the state of Adrar, where the average rainfall did not exceed 6 mm in all seasons of the year during the same period.



Source: Prepared by researchers based on Climate Knowledge Portal of the World Bank

Figure (4): Average monthly rainfall in Algeria for the period (1991-2020)

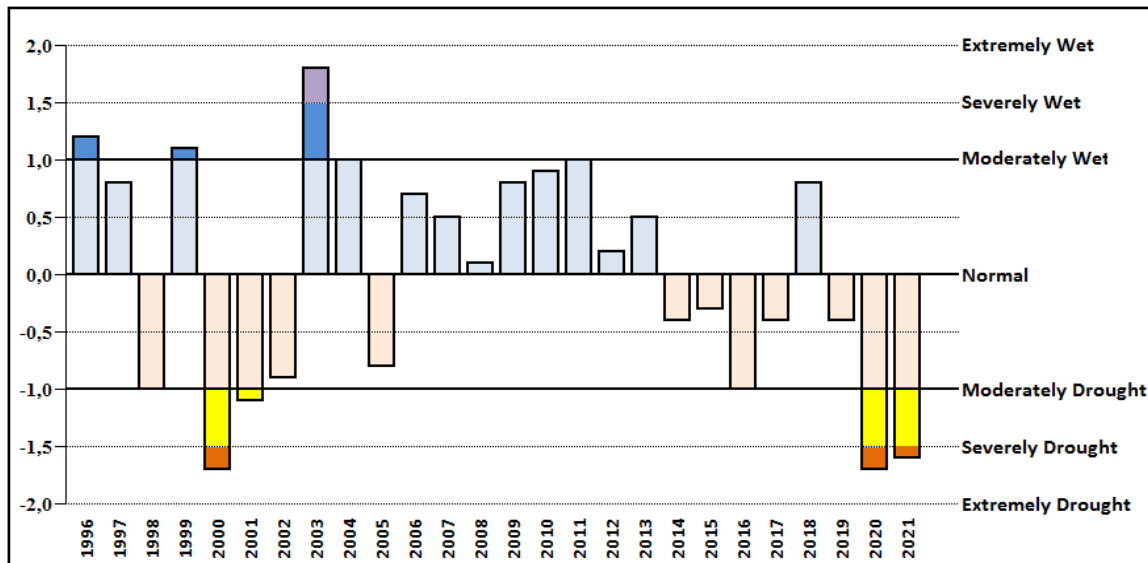
In order to distinguish the types of drought in Algeria during the study period, we use the Standardized Precipitation Index (SPI), which allows assessing climatic drought in terms of time and location based on historical records of rainfall. The SPI describes the number of standard deviations of precipitation recorded each year from the historical average, and the positive (negative) values of the index indicate that the precipitation was higher (lower) than the average precipitation for the entire period, while the mean SPI value is zero in that location and period (Reyes, Rangel, & Herazo, 2022, p. 2).

The value of Standardized Precipitation Index (SPI) for the given year (t) and time scale at a given location is calculated as follows:

$$SPI_t = \frac{P_t - P_{mean}}{\sigma} \dots\dots\dots(1)$$

Where, P_t denotes the average precipitation in a given year (t), P_{mean} is the mean of the observed total precipitation for that period and location, and σ is the standard deviation.

The SPI values are classified into seven different precipitation regimes from severity of a dry to wet event for any given accumulation period and location (European Commission, 2020, p. 4). The SPI indicator computed for the period (1996-2021) in Algeria using EDO (European Drought Observatory) classification scheme is shown in figure (5) below.



Source: Prepared by researchers based on Climate Knowledge Portal of the World Bank

Figure (5): Classification of drought severity according to the Standard Precipitation Index in Algeria for the period (1996-2021)

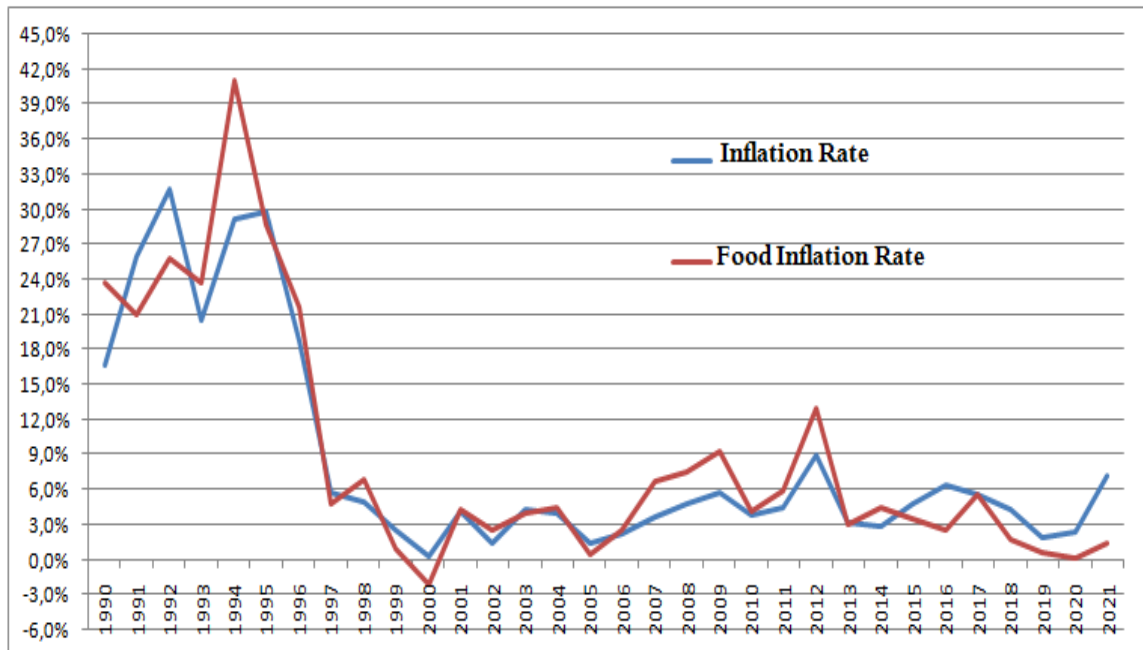
According to the range of Standard Precipitation Index (SPI) values, rainfall in Algeria is characterized by large volatility, but it did not reach the situation of severe drought. The SPI shows the absence of a clear trend of rainfall during the period (1996-2021), as the country witnessed the severely drought in the years 2000, 2020 and 2021, where the precipitation did not exceed 62 mm, while the drought was moderate in 2001.

In 2003, Algeria witnessed severely wet after the precipitation in this year reached the highest value for the entire study period at 107.6 mm. While the wet was moderate in 1996 and 1999, the remaining years were normal precipitation.

5.3. Inflation Rate

The following figure shows the evolution of the overall inflation rate calculated on the basis of the monthly year-on-year of the consumer price index, as well as the inflation rate of food and non-alcoholic beverages, which constitute the first group in the composition of the consumer price index at Algeria's National Office of Statistics. This group includes fresh agricultural products such as vegetables and fruits, as well as meat and fish.

Figure (6) depicts the strong relationship between these two rates, which demonstrated an almost common evolutionary tendency during the study period, indicating that agricultural products play a significant role in explaining fluctuations in overall inflation in Algeria.



Source: Prepared by researchers based on Algerian National Office of Statistics

Figure (6): Evolution of the overall inflation rate and food inflation rate in Algeria for the period (1990-2021)

We can see from the figure above that inflation rate went through two major phases: The first phase (1990-1996) recorded high inflation rates, with the overall inflation rate reaching around 31.7% in 1992 and the inflation rate of food and non-alcoholic beverages reaching 41% in 1994, following Algeria's adoption of a market economy and price liberalization with the removal of government subsidies on some goods.

The second phase (1997-2021) witnessed a decline in inflation rates after the application of the IMF (International Monetary Fund) structural adjustment program, where the overall inflation rate in the year 2000 was about 0.3% with food inflation declining in the same year to -2.1%, and the overall inflation rate recorded low levels compared to the first stage, except for the increase recorded in 2012 by 8.9% due to the rise in food inflation to 13%, and the inflation rate rose to 7.2% in 2021 after the effects of the Corona pandemic (Covid-19) on national economy.

6. Methodology and Data

6.1. Wavelet Analysis

Wavelet analysis is a new technique for studying the relationship between different economic variables. Wavelets are small waves that contain information and data in the fields of time and frequency domain, where the signal's continuity of the wavelet is limited in scale and location (Aguiar-Cornaria, Martins, & Soares, 2010, p. 8).

6.1.1. Continuous Wavelet Transform

The continuous wavelet transform decomposes the two original time series into a function of τ and s in the time and frequency plane. Using Morlet wavelet $\psi(t)$, the continuous wavelet transform (CWT) is defined as (Wang & Li, 2020, p. 527):

$$W_{x;\psi}(\tau, s) = \int_{-\infty}^{\infty} x(t) \frac{1}{\sqrt{|s|}} \psi^* \left(\frac{t-\tau}{s} \right) dt, \dots\dots\dots(2)$$

Where, τ is a translation parameter that controls the location of the wavelet, which means shifting its position, and s is a dilation or scaling factor controlling its width. Scaling means stretching the wavelet (if $|s| > 1$) or compressing it (if $|s| < 1$).

6.1.2. Wavelet Power Spectrum

According to (Aguiar-Cornaria, Rodrigues, & Soares, 2012), the Wavelet Power Spectrum or wavelet periodogram measures the variance distribution of one time series at any time-scale and frequency. The Wavelet Power Spectrum (WPS) is given as:

$$WPS_x(\tau, s) = |W_x(\tau, s)|^2 \dots\dots\dots(3)$$

The cross-wavelet power spectrum depicts the local covariance between two time series at each frequency and time. The cross-wavelet power is given as:

$$W_{xy}(\tau, s) = W_x(\tau, s) W_y^*(\tau, s) \dots\dots\dots(4)$$

Where W_x and W_y^* are the wavelet transforms of the time series x and y , respectively.

6.1.3. Wavelet Coherency

We are interested in deriving the wavelet coherency between climate change and inflation. According to the following mathematical formula, wavelet coherence between two time series is the ratio of the cross-spectrum to the spectrum product of each individual series, allowing the correlation between them to be measured in frequency and time domain (Aguiar-Cornaria, Martins, & Soares, 2010, p. 11):

$$R_{xy} = \frac{|S(W_{xy})|}{[S(|W_x|^2) S(|W_y|^2)]^{1/2}}, \text{ with } \dots 0 \leq R_{xy} \leq 1 \dots\dots\dots(5)$$

Here, S is the smoothing operator in both time and scale. We denote that without smoothing, coherency is identically one ($R_{xy} = 1$) at all times and scales.

According to (Aguiar-Cornaria & Soares) wavelet coherency should be preferred over wavelet cross-spectrum because it is not only normalized by the power spectrum of the two time series, but it also shows strong peaks even for independent processes (Tsai & Chang, 2018, p. 5).

6.1.4. Wavelet Phase-Difference

In order to determine the delays of the oscillations between two time series (x) and (y), the phase-difference calculated by the following formula which is used to determine the type of the relationship (in phase or out-of-phase) and to identify the lead-lag relationships between macroeconomic variables (Aguiar-Cornaria, Rodrigues, & Soares, 2012, p. 10):

$$\varphi_{x,y} = \tan^{-1} \frac{\Im[W_{xy}]}{\Re[W_{xy}]} \dots\dots\dots(6)$$

Where $\Im(W_{xy})$ is the imaginary part of the wavelet transformation, and $\Re(W_{xy})$ is the real part of the transformation, while the phase-difference $\varphi(x,y)$ belongs to the domain $[-\pi, \pi]$ (Batondo & Uwilingiye, 2022, p. 8).

(Aguiar-Conraria & Soares) provide the following rules for interpreting phase differences (Tsai & Chang, 2018, p. 5):

First, when the phase-difference is zero, $\varphi(x,y) = 0$, we say that the two time series move together, this means that $x(t)$ and $y(t)$ show perfect positive correlation.

Second, when the phase-difference is: $\varphi(x,y) = -\pi$ or π , we say that $x(t)$ and $y(t)$ have an antiphase relationship, which means that $x(t)$ and $y(t)$ show perfect negative correlation.

Third, when the phase-differences, both $\varphi(x,y) \in [0, \pi/2]$ and $\varphi(x,y) \in [-\pi/2, 0]$, represent a positive correlation between $x(t)$ and $y(t)$, and the two time series move in phase, the former mean that x is leading y and the latter mean that y is leading x .

Fourth, when the phase-differences, both $\varphi(x,y) \in [\pi/2, \pi]$ and $\varphi(x,y) \in [-\pi, -\pi/2]$, respectively represent a negative correlation between $x(t)$ and $y(t)$, the two time series move anti-phase, the former means that y is leading and the latter means that x is leading.

6.2. Data descriptions

Our study uses monthly data on food inflation rate and climate change variables covering January 1996 to December 2021 with 312 observations. The monthly growth rate of Consumer Price Index of food and non-alcoholic beverages is used to measure the level of food inflation. The main explanatory variables of interest are temperature and precipitation. The descriptions of the variables and data sources are listed in table (1).

Table (1): Descriptions of variables

Variable	Description	Time Period	Data source
Temperature	Average Mean Temperature in °C	1996M01-2021M12	CKP World Bank database
Rainfall	Average Mean Precipitation in mm	1996M01-2021M12	CKP World Bank database
Inflation	Food Consumer Price Index (%)	1996M01-2021M12	Algeria's National Office of Statistics

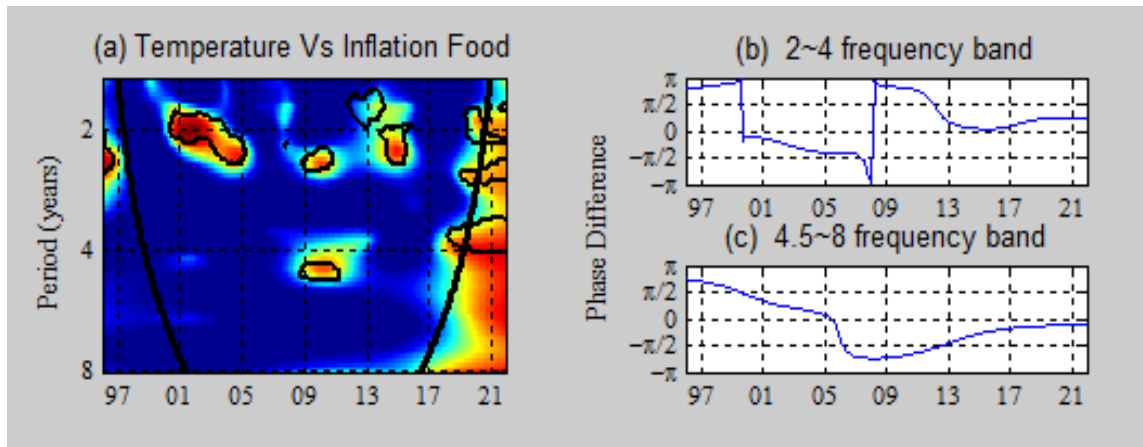
Source: Prepared by researchers

7. Empirical Results

7.1. Wavelet analysis of the relationship between temperature & inflation in Algeria

The figure (7) shows the results of the wavelet analysis of the relationship between average temperature and inflation. On the left (a), we have the color code for cross-wavelet coherency between the two time series ranges from blue (close to zero) which indicates low coherency, to dark red (close to one) which indicates high coherency. This plot is interpreted for the black contour which designate the 5% significance level. The cone of influence is represented by two black lines forming an inverted cone which indicate the region affected by edge effects.

On the right, we have the phase-difference: part (b) represents the phase-difference in the short run at the (2-4) years frequency band (top), while part (c) represents the phase-difference in the long run at the (4-8) years frequency band (bottom).



Source: Prepared by the researchers using (Aguiar-Conraria, & Soares) ASToolbox for Matlab

Figure (7): Wavelet coherency analysis of the relationship between temperature and inflation in Algeria for the period (1996-2021)

The co-movement between temperature and inflation is concentrated in the short run at the (2-4) years frequency band in (1999-2004), where the wavelet coherency is strong and the co-movement is in-phase because the phase-difference shown by part (b) in Figure (7) is between $[0, -\pi/2]$, this means that temperature is leading in-phase during this period that was recorded an increase in temperatures of about 23.8°C in 2001, and was offset by an increase in food inflation rate which reached 4.4% in the same year. In addition, it is the period when agricultural crops were infected during the growing season with a fungal disease known as the Wheat Yellow Rust.

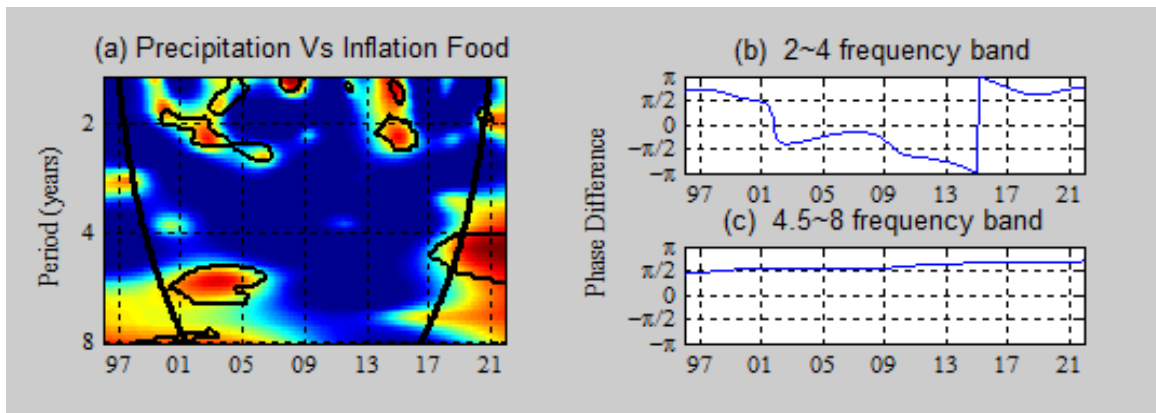
In the second period (2009-2010), the low co-movement relationship is anti-phase in the short run, with the phase-difference located within the range $[\pi, \pi/2]$, indicating that temperature leads inflation out of phase, as the rise in temperature was accompanied by a decline in the inflation rate in this period, which is primarily due to the high amount of rainfall, which increased from 93 mm in 2009 to 95 mm in 2010, and helped to abundant grain production.

The coherency is low in the short run in the third period (2014-2015), where the phase-difference is consistently between 0 and $\pi/2$, suggesting that temperature lags inflation rate in-phase. The decrease in temperature is accompanied by a decline in domestic inflation rate which is explained primarily by a decline in imported inflation, as global markets were characterized in this period by a decline in the prices of the main agricultural products, which included all types of basic products imported by Algeria (meat, grains, milk, sugar and edible oils), as the annual FAO Food Price Index (Food and Agriculture Organization of the United Nations) declined from 6.1% in 2013 to 4.1% in 2014, a situation that was supported by maintaining government subsidies for the prices of imported products and regulatory measures by exempting from customs tariffs and value-added taxes.

While in the long run, the wavelet analysis revealed that the coherency is low in the period (2009-2011), as the phase-difference is within between $-\pi$ and $-\pi/2$, suggesting an anti-phase relation with the inflation rate is leading. This period recorded a rise in temperature against a slowdown in inflation rate, which indicates the presence of other factors that contribute to explaining the fluctuations in food inflation, the most important of which are wholesale prices for vegetables and fresh fruits, international prices for basic agricultural materials imported and the inelasticity of domestic supply to the increase in domestic demand.

7.2. Wavelet analysis of the relationship between rainfall and inflation in Algeria

The following figure shows the results of the wavelet analysis of the relationship between the amount of rainfall and inflation in Algeria during the period (1996-2021).



Source: Prepared by the researchers using (Aguilar-Conraria, & Soares), ASToolbox for Matlab

Figure (8): Wavelet coherency analysis of the relationship between rainfall and inflation in Algeria for the period (1996-2021)

Figure (8) part (a) show a significant relationship between rainfall and food inflation rate appears in the short run at (2-4) years frequency band in (2002-2006), in which the wavelet coherency is weak but in-phase because the phase-differences are located in the interval $[0, -\pi/2]$ indicating that rainfall is leading inflation.

This period recorded an increase in rainfall, which reached about 107.6 mm in 2003, offset by an increase in food inflation rate which reached 4% in the same year, and a decrease in rainfall to 73.2 mm in 2005, accompanied by a slowdown in inflation to 0.5% in period of continuous contraction in the wholesale prices of vegetables and fruits in local markets, from 6.9% in 2002 to 4.2% in 2003, then 2.1% and 1.7% in 2004 and 2005, respectively, in a context characterized by the year 2001 recording the peak of agricultural production with a growth rate of 13.2% and the improvement of animal production, especially meat and milk production, with decline in industrial food products prices.

The coherency is high and anti-phase in the period (2014-2015). Rainfall is leading inflation because the phase-differences are well within the π and $\pi/2$ interval, indicating that the increase in the rainfall is associated with a decrease in inflation. Moreover, the increasing precipitation in this period led to a good agricultural season in a situation characterized by the growth of supply of agricultural production in international markets, which contributed to the decline of international prices of the main imported agricultural products.

In The long run, wavelet coherency analysis shows that the co-movement is strong in the period (2001-2005) where the phase-difference falls within the range $[\pi, \pi/2]$ in an indication that rainfall is leading food inflation out of phase, as this period recorded an increase in rainfall against a slowdown in inflation rate, against the increase in rainfall from 68 mm in 2001 to 107 mm in 2003, the inflation rate decline from 4.4% to 4% in the same period.

It also shows a negative correlation in the period (2017-2018), where the phase-difference is between $[\pi, \pi/2]$, indication that rainfall is leading, as the increase of rainfall that reached 95 mm in 2018 was accompanied by a slowdown in inflation, which fell to 1.8% in the same year, and these favorable climatic conditions helped to record cereal production at its highest level in 2018 at 60.6 million quintals compared to 34.7 million quintals in the last year, and the production of Vegetables and fruits are about 136 million quintals in 2018 compared to 130 quintals in 2017.

8. Conclusion

This paper aims to examine the impact of climate change, particularly temperature and precipitation, on consumer price inflation and their apparent implications for monetary stability in Algeria over the period (1996-2021), using the wavelet analysis approach, which is one of the modern econometric technique in analyzing economic phenomena that do not require the stationarity of time series, as it helps to identify the periods of comovement and the direction of the relationship in the short and long run between economic variables in the time and frequency domain.

Algeria, like other Arab and African countries, is not immune to climate change, as during the period (1990-2021) it witnessed an unprecedented rise in temperature rates, offset by a downward trend of the amounts of rain falling throughout the national territory, which contributed to compromising the ecological balance and biodiversity, the outbreak of fires and the threat of drought in several years. Despite that, seawater desalination projects have helped to mitigate the severity of dry event.

The prices of fresh and agricultural foodstuffs are characterized by high fluctuations, and since they constitute the main component of the consumption basket, this is reflected negatively on the level of overall inflation. Climate change in the main trading partners affects the prices of these agricultural foodstuffs especially wheat and cereals, which exacerbates imported inflation as a result of the deficit in local agricultural production.

Our findings show that temperature has a positive and significant effect on food inflation in the short run at (2-4) years frequency band, as a rise in temperature above moderate levels leads to a lack of agricultural crops, causes fires, and serves as an appropriate medium for the reproduction of harmful insects which is reflected in the prices of agricultural products in the wholesale and retail markets, whereas temperature has no effect on inflation in the long run at (4-8) years frequency band, especially in light of the government's encouragement of many agricultural projects that depend on greenhouses.

The results show also an opposite comovement between rainfall and food inflation in both short run at (2-4 years' frequency) and long run at (4-8 years' frequency), and rainfall is leading food inflation. Whereby, the situational effect of precipitation in sufficient quantities leads to an increase in crops and a large supply of them, which

contributes to low prices; on the other hand, a lack of precipitation leads to a decrease in agricultural crops, and pushes farmers not to venture in coming seasons to plant seeds of products that need to be irrigated with large amounts of water, which leads to a decline in the supply of agricultural commodities and a rise in their prices.

According to our results, Bank of Algeria like other central banks around the world, faces today many challenges in managing monetary policy, particularly in light of the climatic and environmental diversity between the north and south of the country, and that more than 70% of greenhouse gas emissions in Algeria come from the energy sector which is the country's most important sector. Therefore, Algeria's central bank is more obligated than ever to adapt monetary policy to climate change and it must work on developing models that will enable him to anticipate and respond to rising inflation and slowing economic growth as a result of climate change policy.

The Algerian government is required to support Bank of Algeria in its management of monetary policy by preventing and mitigating the impact of climate change through the enactment of environmental laws and regulations, as well as the imposition of taxes on polluting products, and the encouragement of green industrial policy.

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