Modeling the Effects of International Crises and Climate Variability on Food Security in Algeria: An ARDL Approach

BENCHOUK Wahiba
University of Boumerdes (Algeria), w.benchouk@univ-boumerdes.dz
ORCID: https://orcid.org/0009-0002-9150-2497

Received : 08.05.2026 Accepted: 08.06.2026 Published : 01.07.2026

Abstract: This study investigates the impact of international crises and climate fluctuations on food security in Algeria over the period 1990-2024, using wheat import dependence as a proxy indicator. The analysis employs an ARDL model to capture both long-run relationships and short-run dynamics between food security and its key determinants. The main results reveal that rainfall and agricultural productivity are found to significantly decline dependence on wheat imports. Conversely, the impact of oil prices is positive, highlighting the contribution of hydrocarbon incomes towards the financing of food imports in an economic system based on rent. The impact of international crises is also crucial, as it underlines the susceptibility of the Algerian food system to the global disruption. Overall, the research emphasizes the need for integrated policy responses that combine agricultural development, climate adaptation, and reduced dependence on external markets to increase the resiliency of food security in the long term.

Keywords: Food Security; Wheat Import Dependence; Climate Variability; International Crises; ARDL Model.

JEL Classification Codes :Q18; Q54; F14; C22 ; E32.

Corresponding author: BENCHOUK Wahiba, w.benchouk@univ-boumerdes.dz

1. Introduction

The issue of food security has nowadays become one of the most important strategic issues in modern developmental studies, as it is directly related to the social and economic stability of the state and increasingly associated with the capacity of a state to address environmental, economic, and geopolitical challenges.This issue is especially severe in developing countries that rely on imports because the vulnerability of food systems is caused by the interplay of two main factors; the low capacity of the local food production, influenced by the climate variability, and the reliance on the external markets to gain access to basic food products.In this respect, Algeria is an interesting case to study since it still depends on imports of wheat to meet the domestic demand, which is opposed by a weak agricultural background, mainly rain-fed, with high sensitivity to drought and unreliable rainfall patterns.

This problem has become increasingly significant in light of the changes that the world's food system has experienced in recent years. Since the middle of 2020, the Food Price Index (FFPI) of the Food and Agriculture Organization (FAO) has gone up steeply, first due to the supply chain disruptions caused by the COVID-19 pandemic and because of the geopolitical consequences of the war between Russia and Ukraine. According to statistics, average food price inflation in the world increased to 13.6 in January 2023 compared to 2.3 in December 2020, which is still 5.1 points above the general inflation. Low-income countries experienced food price inflation of 25.2 and over 65% of low-income countries and 61% of the lower-middle-income countries recorded food inflation rates exceeding 10%(FAO, 2025). These indicators reveal the growing scales of the shocks to which food systems are now exposed, especially in the economies that are strongly connected to the international markets.

Additionally, the current indicators of global food security also show this alarming situation. According to the FAO's report "The State of Food Security and Nutrition in the World 2025", some 673 million people-equivalent to 8.2%of the world's population-faced hunger in 2024. Nevertheless, even after this relative change, it is much better than the situation was last year; the situation in Africa was still worse, with the rate of undernourishment being over 20, which is almost equal to 307 million individuals. At a broader scale, moderate or severe food insecurity was estimated to affect approximately 2.3 billion people worldwide in 2024, with Africa's rate at 58.9% compared to the global average of 28%. These numbers reflect the still precarious state of global food security and the importance of the need for in-depth country-specific research in countries most vulnerable to fluctuations, Algeria included.

In this context, food security in Algeria is one of the most sensitive strategic issues, considering the persistent gap between domestic production and domestic demand, specifically in the grain sector, mainly wheat. In this regard, Algeria is in a fragile position. The nation depends on imports to supply approximately 75% of the food and over 50% of the caloric demands, which makes it one of the economies in the MENA region that is most reliant on imports of food (Ben Hassen & El Bilali, 2024 ; Bouziane, et al, 2024). It imported food products worth $2829.68 thousand from Russia and $606963.7.68 thousand from Ukraine(World Integrated Trade Solution (WITS), 2026). Wheat takes a central position in this structure, as it is a staple of the national diet, while domestic production is limited to meet domestic demand, and the gap in imports is met mainly by the proceeds of hydrocarbon exports. This situation creates a double vulnerability, first the global food prices are rising, which makes supply pricier; second,

fluctuations in oil prices affect the state's ability to finance imports and maintain the subsidy system.

Furthermore, food security in Algeria is not only vulnerable to external factors but is also exacerbated by internal climatic constraints. More than 90% of agricultural land relies on rainfall, and farming activities are concentrated mainly on the northern regions and semi-arid regions, where rainfall is irregular and relatively scarce. Data also suggest that future climate scenarios such as RCP4.5 and RCP8.5 could lead to a decline in cereal yields of between 18% and 40% by mid-century, with the cost of cereal imports potentially rising by up to $1.2 billion annually(Marouf, 2025). Thus, Algeria's food vulnerability reflects not its dependence on international markets but is also associated with the sensitivity of its domestic production to climate fluctuations, especially in the case of wheat.

Despite the increased amount of literature on food security in Algeria, the accessible results have been on the consequences of climatic changes on agricultural production and others on the consequences of international crises and global changes on food. Nevertheless, few studies have attempted to combine these two dimensions in a single analysis which would draw the line between long-term relationships and short-term fluctuations. This gap is both important from scientific and practical perspective, as assessing the relative weight of climatic and external factors remains essential for setting public policy priorities among agricultural adaption, import management, macroeconomic stability, and the promotion of food security.

In this regard, this paper examines how international crises and climate fluctuation affect food security in Algeria, specifically focusing on the country's reliance on wheat imports from 1990 to 2024. It analyses how domestic grain production's vulnerability to climate conditions and the dependence on international markets create structural weakness in food security. Thus, this research seek to measure the impacts of climate variability on wheat import dependency, determine the economic variables such as world wheat prices and exchange rates, and analyses the effects of major international shocks (e.g., the financial crisis, COVID-19, the war in Russia-Ukraine). It distinguishes between short-term effects and long-term structural relationships to inform more effective agricultural policies.

The paper is divided into different sections which are interrelated. The theoretical and empirical literature concerning climate variability, international crisis, and food security are discussed in the next sections, with a focus on Algeria. The following section gives the data used, the definition of the variables and the econometric methodology that will be used in the analysis. The results section follows and explains the impact of climatic and international variables on short-run and long-run dependence of imports on wheat. Finally, the study concludes with key findings, recommendations, and policy implications for enhancing food security in Algeria.

2. Literature Review

Recent literature reviews indicate that the problem of food security in Algeria is no longer seen as a problem of restrictions of local agricultural production, but as a problem of interaction of climate variability, external shocks, and the structural vulnerability of the food supply system. Previous studies can be categorized into two interrelated areas: (i)studies examining the impact of climate on agricultural production; (ii)studies analyzing the impact of international shocks and import dependence.

2.1. Climate impacts on Agricultural Production

In this regard, various research papers have used dynamic stochastic models in determining the influence of climatic variables on agricultural output. To determine the effect of climate change and innovation on food production in Algeria between 1970 and 2019, Bouznit and Aïssaoui (2024)employed an ARDL model, which concluded that both rainfall and human and physical capital had a positive and statistically significant effect on food production in the long-run, but average temperature did not. The findings also reveal that the most significant determinats of production in the short run are rainfall and physical capital, which can be justified by the fact that climate impacts food security mainly via the domestic production channel. These results are corroborated by an earlier contribution from Bouznit et al. (2022), who used a simultaneous equation model to study the relationship between climate change and agricultural production in Algeria over the period 1966-2016. The findings revealed that rainfall positively influences agricultural productivity, and carbon dioxide emissions have a negative impact because of their contribution to an increase in temperature. The study also revealed an indirect pathway whereby rising per capita income leads to higher emissions, which subsequently have negative impacts on agricultural productivity. This finding is particularly significant as it highlights the interdependence between economic growth and environmental pressures in the Algerian economy.

Onyeaka et al. (2024) analysed the effects of climate change on foood insecurity in Africa, stressing its impacts on the four pillars of food security (availability, accessibility, utilization, and stability). The review found that climate-related changes in temperature, rainfall, and weather patterns significatly reduce agricultural production, while poverty, population growth, enadequate early warning systems, and weak agricultural infrastructure further shaping food insecurity. Moreover, the study showed that climate change increases food prices, declines availability, and wider inequality, thereby increasing risks of social and political instability. Vulnerable populations, especially women, were identified as the most affected.Further, Mekki (2024) investigated the impact of climate change on food security in Algeria, focusing on the effects of rising temperatures and prolonged drought. It clarified the key concepts of climate change, food security, and self-suffiency, and evaluated the implications of climate stress on the agricultural sector. The study further highlighred the policy measures undertaken by the Algerian government to mitigate these risks, particularly through diversifying agricultural production and promoting farmaing in desert regions to compensate for food shortages.

Simillary, Omokaro (2025) analysed the impact of climate variability on agriculture and food security in Nigeria, and identifing effective adaptation strategies to reduce these effects. The results showed that erratic rainfall, rising temperatures, and extreme weather events significantly decline agricultural productivity, leading to reduced crops yieds particularly maize, cassava, and rice, rising pest and disease pressure, and land degradation. The study also conducted that livestock production is increasingly constrained by heat stress and declining feed availability, further intensifing food security challenges in Nigeria.

Furthermore, Marouf (2025) integrated the biophysical DSSAT model with the multi-criteria SWOT-AHP framework to assess the vulnerability of cereals production in northern Algeria to climatic conditions in the future. The study found that grain yields could decline by 18 to 40 percent in the mid-century, with consequent increases in the import bill and losses in agricultural employment. It also demonstrated that the most cost-effective and profitable

adaptation options are drip irrigation and drought-tolerant seeds. This paper highlights the impact of climate change does not stop at the farm level, but extends to the trade balance and overall food security.Additionaly, Ouzani et al. (2025)applied the Soil-Water-Atmosphere-Plant (SWAP) model to the interdependence between climate change and wheat production in semi-arid areas of Algeria over the period 2014-2024. The simulation showed that by optimizing the irrigation scheduling, especially using a nine-day irrigation cycle, water productivity could be increased and yield stability enhanced. This result indicates that some of the climate effects can be reduced with the help of technical water management, and investment in smart irrigation is one of the major factors in ensuring food security.

Moreover, within the framework of national food security goals, Bourouba et al. (2025) used an ARDL model to estimate the determinants of grain production in Algeria during 2000-2023, with a focus on the role of greenhouse gas emissions, precipitation, and cultivated land area. The findings indicated that rainfall and cultivated land area positively influence grain production in both the short and long term, whereas CO_2 had a negative impact in the short term. The significance of this study lies in its linking of agricultural production to national food security, within an approach that combines climatic factors with factors related to land use.

Benbekhti et al., (2024) investigated the role of sustainable agricultural practices in advancing food secuity in Algeria within the framework of SDG 2. Using a VAR model for the peiod 2010-2022, the findings showed that government expenditure on agriculture positively affects agricultural productivity and food security in the short term, although its long term impacts declines without sustained investment and adaptive measures. The results also indicate that non-oil GDP growth has a variable effect on food security, which confirm the need for economic diversification.

Overall, it can be concluded that rainfall plays a major role in clarifying the agricultural performance in Algeria; temperature, emissions, and drought are structural limits to production, which explains why climate variables should be included in any standard model describing food security vulnerabilities or wheat import dependency.

2.2. External Shocks and Trade-Based Vulnerability

Algeria food system relies heavily on imported cereals, vegetable oils and other food commodities. This makes its food security very vulnerable to international markets. This section reviews the literature on how external shocks, such as the COVID-19 pandemic, the Russia-Ukraine conflict and global commodity price spikes have affected food security, in Algeria and similar economies that depend on imports.

In this context, Rahmouni (2020) presented a descriptive-institutional analysis of food security situation in Algeria, and has concluded that the country is characterised by structural fragility due to its high reliance on food imports and low ability of the agricultural sector to satisfy domestic demand. This study also showed that institutional imbalances and poor coordination between policies and investment increase Algeria's vulnerability to external shocks.

Regarding the pademic's household-level effects in Algeria, Touidjeni et al., (2022) used a survey of Algerian households, as a source of data on household perceptions of food security during the pandemic. The findings revealed that availability of food was still relatively good, however, there wa a strong impact on financial access to food, and less impact on the food quality. This result shows that purchasing power and stability of supply were the most significant consequences of the pandemic shock instead of the absolute shortage of products.

Additionaly, at the international scale, Saboori et al., (2022)conducted a cross-country comparative analysis of the effects of COVID-19on food security and used 102 countries of data, taking into consideration the influence of inflation, urbanization, agricumtural land, and ecinomic growth. The results showed that countries with pre-existing food insecurity were more vulnerable to further deterrioration during the pandemic, and that inflation was among the most powerful explanatory channels for reduced food affordability. These cross-country findings provide contest for interpreting Algerian's experience, where public fiscal capacity helped mitigate the shock but did not prevent price pressures from being passed on to households. In a comparative study, Ouko and Odiwuor (2023) also discussed the combined impact of climate change, COVID-19, and the Russia-Ukraine war on food security in Africa. Through price volatility and distruptions to the supply chain, the study highlighted that these shocks do not act separately but interact to create the multiplicative and nonlinear effects.

Concerning to the Russia-Ukraine war, Ben Hassen and El Bilali (2024) provided an in-depth analysis of the effects of the war on food security in North Africa. The analysis revealed that the war had an impact on food systems with the disruption of wheat and oil markets and the increase of the prices of fertilizers and maritime transport. It further showed that Algeria could absorb a portion of the shock in the short term due to its financial reserves; nevertheless, the further increase in global prices poses a structural risk to the food security that depends on subsidies and imports.

Similary, Bouziane et al. (2024) used a descriptive-analytical method to determine how the food security of Algeria is susceptible to internal and external shocks. The reseach concluded that the level of food security in Algeria seems acceptable on the surface, but it is vulnerable and lacks resilience to overcome the crisis, mainly because of a significant dependence on imports and the marginalization of agriculture within the national development strategy.

In this context, AL-Rousan et al. (2024) also investigated how the Russo-ukrainian war, COVID-19, and oil price volatility have affected global food security, with a particular focus on food price indices. Using Pearson correlation, linear regression, and SARIMA forecasting models, the study analyse the relationship between Brent crude oil, pandemic and war shocks, and six global food indicators. The results show that COVID-19 and the Russo-ukrainian war contribute positively to increasing food prices, however Brent oil prices have the strongest effect on food price movements. These findings can be directly applied to our research as it confirms the concept of studying international crisis in a unified framework instead of focusing on a crisis on its own.

Previous literature reviews indicate that the fragility of food security in Algeria is linked not only to weak domestic food production but also to the fact that it is an economy that relies extensively on imports of grains and stable foods, making it highly sensitive to global price volatility and geopolitical crises. Finally, earlier investigations reveal three main findings. First, climatic fluctuations, particularly changes in rainfall, rising temperatures, and drought, directly affect agricultural production and grain yields in Algeria. Second, the global shocks, including the pandemic, the Russia-Ukraine war, and the increase in world prices, are explained through the international channel and the price volatility into the Algerian domestic economy, mostly via imports. Third, Algeria's ability to absorb these shocks remains associated with the nature of public policies, agricultural investment, water management, financial reserves, and the efficiency of the institutions.

Although the importance of these studies, most of them have focused on the effect of climate or external shocks individually, while there remains a need to have a common standard model that evaluates the comparatives effects of climate changes and international crises effect on a single dimension of food security in Algeria. This is where the current study contributes by analyzing this relationship through a dynamic model, incorporating climate and economic factors, as well as international shocks, over the period from 1990 to 2024.

3. Data and Methodology

This study employs a quantitative research framework to investigate the effects of international crises and climate fluctuations on food security in Algeria during the period (1990-2024). A quantitative time-series approach is particularly appropriate, as it enables the systematic modelling of dynamic relationships among macroeconomic and agricultural variables over time (Creswell & Creswell, 2018).

3.1. Data Sources and Variable Description

The data of the study was collected from different datasets. Macroeconomic and climate indicators, including the real effective exchange rate, global wheat prices and rainfall were obtained from the World Bank's world development indicators and commodity price database (World Bank, 2026). Agricultural data, such aswheat import dependence and yield of wheat were sources from USDA databases (USDA, 2026). While, Oil prices (Saharah Brent) were collected from OPEC reports. Table 1 represents the variables used in the study:

Table 01.Variable Specification and sources

The variable	Description	Source
IMP	The wheat import dependence	USDA
YIELD	The wheat productivity	USDA
Rain	The amount of rainfall	World Bank
REER	The real effective exchange rate	World Bank
OIL	The Prices of Sahara Brent	OPEC
WPRICES	The global wheat prices	World Bank

Source: Prepared by the author.

This study adopts an empirical framework based on the evidence of food security and external shocks, productivity, and climatic variability. Food security in Algeria is represented by wheat import dependence as dependent variable, reflecting Algeria's structural reliance on external markets. Meanwhile, explanatory variables including yield which reflects agricultural productivity, rainfall is the proxy for climatic conditions, the real effective exchange rate reflects purchasing power and the competitiveness of the country, and this affects the affordability of imports. Whereas, international wheat prices capture external market shocks; however, oil prices reflect Algeria's capacity to finance imports through oil revenues.

In order to capture the effects of major global events, a dummy variable was used to reflect the international crises including 2008 financial crisis, COVID-19 pandemic and Russia-Ukraine War. This has had a significant impact on world food markets and supply chains, thereby influencing food security.

3.2. Model Specification

The model formulation process is one of the most critical stages in model constructing, as it involves identifying the independent variables that may influence the dependent variable. Based on theoretical approaches and previous studies, the following model was developed:

$$IMP = f(YIELD, RAIN, OIL, REER, WPRICES, D_{Crises},)$$

After applying the logarithm to the equation, it takes the following form:

$$\mathrm{l}IMP =$$

Where: ε is the stochastic error correction term and $\beta_i$is the long-run elasticity coefficients to be estimated.

For examining the impact of climate fluctuations and external shocks on food security in Algeria, an autoregressive distributed lag (ARDL) model was applied, which is more appropriate for time-series data. The study incorporated the natural log of all variables to reduce the intensity of the results, and the ARDL model is represented as follow:

$$\begin{aligned}\Delta LIMP_t = \alpha_0 &+ \sum_{i=1}^{p} \alpha_1 \Delta LIMP_{t-i} + \sum_{i=1}^{q1} \alpha_2 LYIELD_{t-i} + \sum_{i=1}^{q2} \alpha_3 \mathrm{l}RAIN_{t-i} + \sum_{i=1}^{q3} \alpha_4 \mathrm{l}OIL_{t-i} \\ &+ \sum_{i=1}^{q4} \alpha_5 \mathrm{l}REER_{t-i} + \sum_{i=1}^{q5} \alpha_6 \mathrm{l}WPRICES_{t-i} + \sum_{i=1}^{q6} \alpha_7 D_{crises_{t-i}} + \beta_1 LIMP_{t-i} \\ &+ \beta_2 LYIELD_{t-1} + \beta_3 \mathrm{l}RAIN_{t-1} + \beta_4 \mathrm{l}OIL_{t-1} + \beta_5 \mathrm{l}REER_{t-1} + \beta_6 \mathrm{l}WPRICES_{t-1} \\ &+ \beta_7 D_{crises_{t-1}} + \varepsilon_t\end{aligned}$$

Where the Δ is the first difference; the intercept is α_0 ; p,q_1 …. q_6 are the optimal lag lengths; α_i are the short-run dynamics coefficients; β_i are the long-run coefficients; ε_t is the noise error term

Why is the ARDL Bounds Testing Approach appropriate for this study?

The ARDL model is suitable for this analysis because of the following reasons (Pesaran & Shin, 1999; Pesaran, et al., 2001):

- The sample size is small because the data are annual cover only the period from 1990 to 2024.
- The ARDL model can include variables that stationary I(0) and variables that are stationary at the first difference I(1).
- The model also allows for the relationship to be examined in both the short and long run.
- The ARDL approach can include dummy variables for global crises.
- However, the fundamental condition is that no variable should be of the second order I(2).

Stationarity was first deployed using the Augmented Dickey-Fuller and Phillips-Perron tests to ensure that no variable is integrated beyond order one. Lag section was based on the Akaike Information Criterion, and cointegration was then tested using the bounds testing procedure, with inference based on established critical values (Pesaran et al., 2001; Narayan, 2005).

Where contegration was confirmed, an error correction model (UECM) was estimated to capture short-run adjustments toward long-run equilibium. A negative and significant error correction term inficates convergence and model stability (Engle & Granger, 1987). Model robustness was evaluated through standard diagnostic tests for serial correlation, hetroscedasticity, normality, and functional specification. Further, stability tests such as CUSUM and CUSUMSQ (Brown et al, 1975).

4. Results and Discussion

The results of the descriptive statistics for the study data covering the period 1990-2024, which included 35 annual observations, revealed a set of important characteristics that reflect the nature and variability of the variables under study. The average wheat import dependency IMP was approximately 74.01 with a minimum of 53.135 and a maximum of 96.787, reflecting a high degree of food dependency on foreign sources, as well as significant fluctuations indicating that food security is affected by varying economic and climatic conditions. Statistics also show that WPRICES, REER and RAIN have the greatest mean of 209.203, 112.879 and 81.781, respectively, making them the most volatile factors. This suggests that external market shocks, real effective exchange rate and climatic volatility play a major role in influencing food security. OIL also showed significant volatility, averaging 53.55, reflecting the hydrocarbon dependent nature of the Algerian economy and consequently the impact of these prices on the financing capacity for imports. The descriptive statistics are summarized in Table 02.

Table 02. Descriptive statistics

Variable	Mean	Median	Standard Deviation	Max	Min
IMP	74.01	73.342	9.180	96.787	53.135
YIELD	0.2657	0.3700	0.3163	0.7147	-0.6931
RAIN	81.781	84.300	14.056	107.500	57.320
OIL	53.552	52.790	32.562	112.920	13.019
REER	112.879	102.924	25.194	220.958	86.799
WPRICES	209.203	192.040	79.042	430.000	112.040

Source : Prepared by the Author based on the outputs of the Eview12 program.

According to augmented Dickey-Fuller (ADF) and Philips Perron (PP) tests, there is a mix of results on stationary tests used. Findings show that LIMP, LRAIN, LREERand WPRICES are stationary at level, while LOIL is stationary at the first order. In general, These results indicate that the variables are integrated to varying degrees between I(0) and I(1), which meets the basic condition for applying the ARDL model. Table 03 represents the t-Statistic results of (ADF) and (PP)unit root test.

Table 03.ADF and PP Unit root Test Results

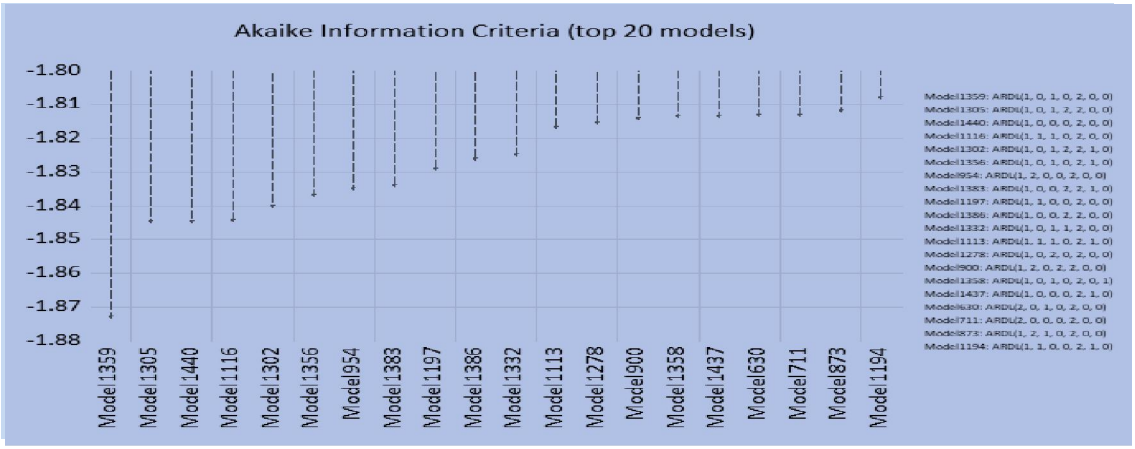
Variable	Standard unit root (ADF)		Standard unit root (PP)	
	Level	First difference	Level	First difference
LIMP	-6.246*	-7.792*	-6.246*	-15.613*
LYIELD	-6.422*	-9.755*	-6.422*	-34.811*
LRAIN	-3.802**	-8.463*	-3.771**	-22.825*
LOIL	-2.059	-5.623*	-2.059	-5.316*
LREER	-1.559	-9.916*	-5.751*	-20.008*
LWPRICES	-6.107*	-5.401*	-7.640*	-26.622*

Source : Prepared by the Author based on the outputs of the Eview12 program.

*,**,*** indicate the 1%, 5% and 10% significant levels respectively.

The ARDL technique developed by (Pesaran & Shin, 1999; Pesaran, et al., 2001) was employed to ensure the existence of the long run relationship and capture short run dynamics. The optimal lag lengths for the ARDL model were determined based on the Akaike Information Criterion (AIC). The maximum number of lags was set at two for both dependent and independent variables to avoid losing degrees of freedom. The variation in the number of lags among variables reflects differences in the speed at which economic effects are transmitted. resulting in the following model using the Eview12 software: **ARDL (1, 0, 1, 0, 1, 2, 0, 0)**.

Figure 01. Optimal ARDL model within 20 selected models



Source : Outputs of Eview12 program.

Afterensuring the stability of the time series and determining the optimal lag lengths using the AIC, an ARDL model was estimated to measure the impact of economic and climatic variables and international crises on the food security index in Algeria, as represented by the wheat import dependency ratio. This model allows for the study of the dynamic impact of independent variables by incorporating both current and lagged values for each variable, thereby capturing both immediate and cumulative effects in the short term.Table 04 represents the results of the ARDL bound test.The resultsreveals a cointegration relationship between variables at the 5% significance level, as the calculated statistical value (F-statistic=14.240) is greater than the tabular upper limit value.

Table 04. ARDL Bound Test for Cointegration

Model	F value	Sig	Critical Bound Value	
			Lower I(0)	Apper I (1)
ARDL (1, 0, 1, 0, 1, 2, 0, 0) K=6	14.240	10%	1.99	2.94
		5%	2.27	3.28
		1%	2.88	3.99

Source: Prepared by the Author based on the outputs of the Eview12 program.

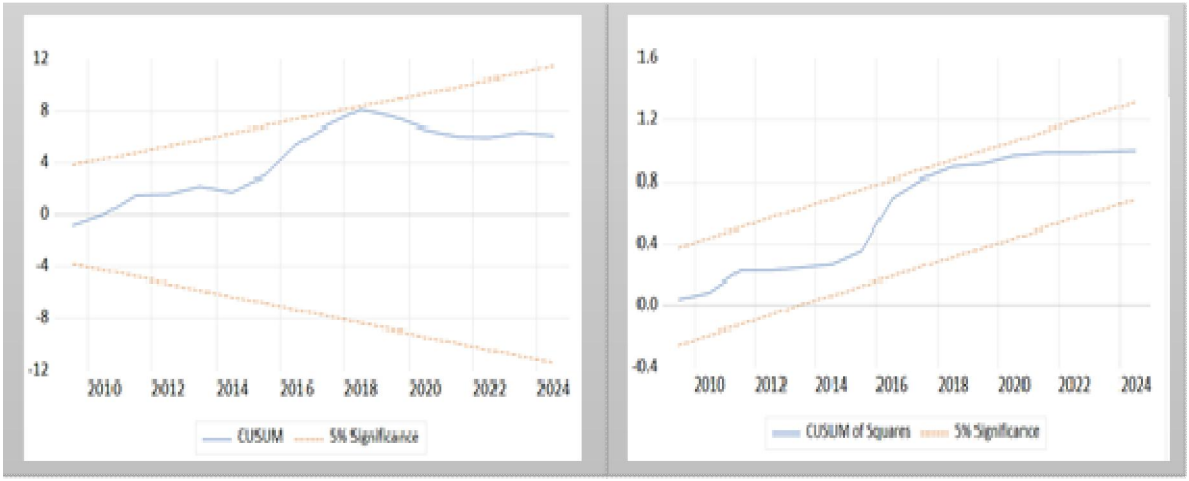
The estimated ARDL model has passed several diagnostic tests (i.e., LM, ARCH and Normality tests), which indicate no evidence of serial correlation, heteroscedasticity problem and the residuals are normally distributed (see table 05). Moreover, the CUSUM and CUSUMsq statistical tests indicate that the model is overall stable as shown in Figure 02.

Table 05. Diagnostic test results

Serial correlation (LM test)	ARCH	JarqueBera
F-Statistic (0.580)	F-Statistic (0.271)	Jarque-Bera (0.369)
Prob.F(2,20)	Prob.F(1,30)	Prob
(0.568)	(0.606)	(0.831)

Source: Prepared by the Auther based on the outputs of Eview12 program.

Figure 02. CUSUM and CUSUM sq test results



Source : Prepared by the Auther based on the outputs of Eview12 program.

The confirmation of the cointegration relationship allowed estimating the elasticity of the long-run relationship and using an error correction model (ECM) to analyze short-run dynamics and the speed at which the system returns to equilibrium. Table below show the long-run coefficients.

Tables 06. ARDL long-run coefficients

Variable	Coefficient	Std Error	T-Statistic	Prob
LYIELD	-0.173	0.093	-1.865	0.075
LRAIN	-0.414	0.086	-4.798	0.000
LOIL	0.078	0.032	2.437	0.023
LREER	0.225	0.196	1.147	0.263
LWPRICES	0.005	0.007	0.805	0.429
	-0.092	0.035	-2.612	0.015
	4.796	1.053	4.552	0.000

$$EC = LIMP - (-0.1739^{*}LYIELD - 0.4145^{*}\,\text{LRAIN} + 0.0784^{*}\text{LOIL} + 0.2257^{*}\text{LREER} + 0.0060^{*}\text{LWPRICES} - 0.0921^{*}\text{DCRISIS} + 4.7966)$$

Source: Prepared by the Auther based on the outputs of Eview12 program.

The results of the long-run elasticity estimates indicate that Algeria's dependence on wheat imports is affected by climate and economic factors to varying degree. The elasticities show that improvements in agricultural productivity and rainfall by 1% lead to significant reduction in import dependence by 17.3% and 41.4% respectively. Which confirms the crucial role of climatic factors in enhancing food security through the domestic production channel. These findings are in line with the results of Bourouba et al. (2025) and Bouznit et al. (2022). Further it

consistent with applied studies that have highlighted the vulnerability of grain production in semi-arid regions of Algeria, such as Marouf (2025) and Ouzani et al. (2025). In contrast, oil prices have a positive and significant impact, reflecting the particularity of the Algerian economy, where rising oil revenues help finance imports rather than reduce them. Thus, a 1% increase in oil prices boosts import dependence by 7.8%. This result consistent with the studies' findings by Ben Hassen and EL Bilali (2024) and Rahmani (2020).

The results also highlight that international crises have a negative and significant impact on wheat import dependency. This paradox is resolved by recognizing that the observed decline does not reflect improved domestic food production but rather reflects permanent decline adjustments in import capacity resulting from price shocks, supply disruptions, and financial constraints. Although this finding appears to differ from some studies that have showed that international crises, such as COVID-19 and the Russia-Ukraine war, increase the vulnerability of food-importing countries, it does not necessarily contradict them. Studies by Touidjen et al.(2022) and Ben Hasen and Bilali (2024) have shown that Algeria was able to relatively absorb some structural risks associated with dependence on international markets. Meanwhile, neither global wheat prices nor the real effective exchange rate showed a significant impact, which can be explained by the role of government policies in absorbing external shocks, including subsidies, importation policies, and domestic price controls. Overall, these flexibilities confirm that food security in Algeria is determined by complex interaction between domestic climatic factors and external economic shocks.

Tables 07. Results of the short-run Dynamics

Variable	Coefficient	Std Error	t-Statistic	Prob
D(LRAIN)	-0.446	0.074	-5.975	0.000
D(LREER)	0.098	0.206	-0.475	0.638
D(LREER(-1))	0.362	0.112	3.219	0.003
$ECM(-1)^*$	-1.463	0.119	-12.254	0.000
R-squared (0.860)				
Adjusted R-squared (0.846)				

Source: Prepared by the Auther based on the outputs of Eview12 program.

The short-run dynamics are reported in Table 7, indicating that rainfall and real effective exchange rate are significantly contributing to food security in the short-run, while others affect food security only in the long-run. This result confirms that positive climate shocks are rapidly reflected in agricultural production, particularly in rain-fed agricultural system. Further the lagged variable D(LREER(-1)) shows a positive and significant effect, indicating a lagged effect of the exchange rate where past changes affect import dependence in current period. ECM coefficient(-1) is equal to (-1.46), which is negative and significant at 1%, showing that the variables are in long term equilibrium. The estimated value of this coefficient suggests that 146% of short term imbalance is corrected in each period, suggesting a fast adjustment of the system.

5. Conclusion

This study aims to measure the impact of international crises and climate variability on food security in Algeria during the period 1990-2024, using wheat import dependence as a proxy indicator. By applying an ARDL approach, the analysis distinguished between long-run structural relationship and short-run dynamics, allowing for a more comprehensive

understanding of the determinants of food vulnerability. The empirical results confirm the presence of long-run relationship between food security and its key climatic, economic and external determinants, indicating that food security in Algeria follows a stable but vulnerable structural path. In the short run, rainfall remains the most dominant variable, reflecting that food security is sensitive to climatic changes. Overall, the findings, highlight that Algeria's food security remains structurally fragile, shaped either by domestic production constraints or by the strong exposure to shocks in the global food market.

5.1.Findings: The study's key findings are as follows:

- Rainfall and agricultural productivity have a negative and significant impact on the dependence on imports of wheat, indicating that increases in climatic conditions and the domestic agricultural performance decrease the reliance on imports.
- Oil prices have a positive and significant effect, as it reflects the rentier characteristics of the Algerian economy, where increased hydrocarbon revenues enable the financing of food imports instead of dependency reducing.
- International crises such as COVID-19 and Russian-Ukrainian war have a significant influence, which confirms that the impact of global shocks on food security is crucial.
- Exchange rate and world wheat prices have limited long-run significant, which could reflect the contribution of state intervention, subsidies and price stabilization policies to mitigate external shocks.
- The error correction term is negative and significant which confirms that a quick adjustment in the direction of the long-run equilibrium is taking place.

5.2.Policy Implications and Recommendations

According to the results, several key policy implications can be identified to strengthen food security in Algeria. Emphasis should be placed on augmenting agricultural productivity particularly through investment in technology, irrigation and climate resilient practices. Meanwhile, it is necessary to enhance climate adaptation strategies, including enhanced water management and the implementation of drought resistant crops. The need to decline structural reliance on food imports should be achieved through favoring local production and diversification of agricultural activities. Moreover, enhancing strategic food stocks and increasing the import sources will be more useful in reducing the external shock and geopolitical risk factors. It is also important to reform subsidy and pricing mechanism to make it more efficient and targeted to guarantee long-term sustainability.

6. Bibliography Lists

AL-Rousan, N., AL-Najjar, H., & AL-Najjar, D. (2024). The impact of Russo-Ukrainian war, COVID-19, and oil prices on global food security. *Heliyon, 10*(8).

Ouzani , Y., Hiouani , F., Junaid Ahmad, M., & Sook Choi , K. (2025). Impact of Climate Change on Wheat Production in Algeria and Optimization of Irrigation Scheduling for Drought Periods. *Water, 17*(11), 1658. doi:https://doi.org/10.3390/w17111658

Ben Hassen, T., & El Bilali, H. (2024). Conflict in Ukraine and the unsettling ripples: implications on food systems and development in North Africa. *Agriculture & Food Security, 13*(16). doi:https://doi.org/10.1186/s40066-024-00467-3

Benbekhti, S., Bouknadil, M., Boulila, H., & Zeghoudi, A. (2024). Socioeconomic Challenges on Algeria's Progress toward SDG2 (Zero Hunger): Public Spending, Agriculture, and Economic Resilience. *SocioEconomic Challenges, 8*(4), 1-18. doi: https://doi.org/10.61093/sec.8(4).1-18.2024

Bourouba, K., Fouzi Tahar, A., Hamza, A., & Emad Suliman, S. (2025). Assessing the Impact of Climate Change on Food Security Indicators: An Empirical Study in Algeria (2000-2023). *Journal of Information Systems Engineering and Management, 10*(49s), 2468-4376.

Bouziane, F., Laallam, A., Oussedik, M., Ouassaf, S., & Khababa, N. (2024). Food Security in Algeria: An Analytical Study. *Journal of Ecohumanism, 3*(7), 2647-2660. doi:https://doi.org/10.62754/joe.v3i7.4407

Bouznit, M., & Aïssaoui , R. (2024). The impacts of climate change factors and innovative capabilities on food production in Algeria: evidence from ARDL model. *Environment, Development and Sustainability, 26*, 23889–23908. doi:https://doi.org/10.1007/s10668-023-03627-w

Bouznit, M., Elaguab, M., Mostefa Selt, M., Himrane, M., & Aïssaoui , R. (2022). Climate Change and Agricultural Production in Algeria. In W. Leal Filho, & E. Manolas (Eds.), *Climate Change in the Mediterranean and Middle Eastern Region* (pp. 249–268). Springer, Cham. doi:https://doi.org/10.1007/978-3-030-78566-6_12

Brown, R. L., Durbin, J., & Evans, J. M. (1975). Techniques for testing the constancy of regression relationships over time. *Journal of the Royal Statistical Society: Series B,, 37*(2), 149–163. doi:https://doi.org/10.1111/j.2517-6161.1975.tb01532.x

Creswell, J. W., & Creswell, J. D. (Eds.). (2018). *Research design: Qualitative, quantitative, and mixed methods approaches.* SAGE Publications.

Engle, R. F., & Granger, C. J. (1987). Co-integration and error correction. *Econometrica, 55*(2), 251–276. doi:https://doi.org/10.2307/1913236

FAO. (2025). *The State of Food Security and Nutrition in the World 2025.*

FAO. (2026). *FAOSTAT statistical database*.

Marouf, A. (2025). Economic Vulnerability of Cereal Production in Northern Algeria under Climate Change: Cost-Benefit Analysis of Adaptation Strategies Using DSSAT-SWOT. *Research on World Agricultural Economy, 6*(4), 348–361. doi: https://doi.org/10.36956/rwae.v6i4.2278

Mekki, A. (2024). The Impact of Climate Change on Food Security in Algeria (Analytical Study). *Finance and Business Economics Review, 8*(4), 26-36. doi:10.58205/fber.v8i4.1897

Narayan, P. K. (2005). Saving–investment nexus. *Applied Economics, 37*(17), 1979-1990.

Omokaro, G. (2025). Multi-impacts of climate change and mitigation strategies in Nigeria: agricultural production and food security. *Science in One Health, 4*. doi:https://doi.org/10.1016/j.soh.2025.100113

Onyeaka, H., Nwauzoma, U., Akinsemolu, A., Tamasiga, P., Duan, K., Al- Sharify, Z., & Siyanbola, K. (2024). The ripple effects of climate change on agricultural sustainability and food security in Africa. *Food and Energy Security*, 1-15. doi:DOI: 10.1002/fes3.567

Ouko, K., & Odiwuor, M. (2023). Contributing factors to the looming food crisis insub-Saharan Africa: Opportunities for policy insight. *Cogent Social Sciences, 9*(1). doi:https://doi.org/10.1080/23311886.2023.2173716

Pesaran, M. H., & Shin, Y. (1999). *ARDL modelling approach.*

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approach. *Journal of Applied Econometrics, 16*(3), 289-326.

Rahmouni, M. (2020). Food Security in Algeria: Concept Review and Measurement Indicators. *Economic and Managerial Research, 14*(3), 235-248.

Saboori, B., Radmehr, R., Zhang, Y. Y., & Zekri, S. (2022). new face of food security: A global perspective of the COVID-19 pandemic. *Progress in Disaster Science, 16*.

Touidjeni , Z., Boufelta , M., & Mebarki, L. (2022). The food security of Algerian households in the light of the COVID-19 pandemic: An exploratory study. *International Journal of Food and Agricultural Economics (IJFAEC), 10*(1128-2022-972), 185-203.

USDA. (2026). *World markets and production databases*.

World Bank. (2026). *World development indicators*.

World Integrated Trade Solution (WITS). (2026, 04 17). Retrieved from https://wits.worldbank.org/CountryProfile/en/Country/DZA/StartYear/2017/EndYear/2021/TradeFlow/Import/Partner/ALL/Indicator/MPRT-TRD-VL