Economic studies Journal
ISSN 2602-7925
https://www.asjp.cerist.dz/en/PresentationRevue/417

Volume: 20/ N°: 1 (2026), p 266-282

An Econometric Study of the Impact of Economic Growth, Climate Change, and Demographic Growth on Freshwater Consumption in Algeria During the Period: 1990-2020

Lounnas Soufyane *

University of Mila, Laboratory for Studies of Economic Diversification Strategies for Achieving Sustainable Development, (Algeria)

lounnas.soufyane@centre-univ-mila.dz

Bouchelaghem Amirouche

University of Constantine 2, Laboratory of Economics and Business Management, (Algeria)

amirouche.bouchelaghem@univ-constantine2.dz

Abstract ;

The objective of this study was to quantify the effects of economic and population growth under climate variability on annual freshwater abstractions in Algeria over the 1990-2020 period. Utilizing the Autoregressive Distributed Lag (ARDL) modeling approach, the findings demonstrate statistically significant positive long-term impacts of temperature and demographic expansion. The empirical results indicate that annual freshwater withdrawals increase by 4.23 units per unit increase in temperature and by 3.97 units per unit increase in population growth. While economic growth shows a positive coefficient, it lacks statistical significance. Short-run dynamics reveal a positive association between temperature and annual freshwater withdrawals, with each unit increase in temperature corresponding to a 0.47-unit increase in water abstractions. These findings establish climate change as a principal determinant of escalating water stress, attributed to reduced precipitation and elevated temperatures, thus highlighting the critical necessity for sustainable interventions to ensure water security.

Article info

Received 06/12/2025

Accepted 07/04/2026

Keyword:

- ✓ Freshwater consumption;
- ✓ Economic growth;
- ✓ Climate change;
- ✓ Algeria ;
- ✓ ARDL.

* Corresponding author

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

1. *Introduction*

Population growth is one of the most pressing challenges confronting policymakers globally, serving as a critical factor in achieving development objectives. The global population has more than tripled since the mid-20th century. According to a United Nations report on population growth, the global population reached 8 billion by mid-November 2022, a substantial increase from 2.5 billion in 1950. Projections estimate that this figure will rise to 10 billion by 2050. This rapid growth necessitates urgent measures in development planning to mitigate its negative impacts on sustainable development goals (UN DESA, 2022).

Algeria, too, has witnessed significant demographic changes in recent decades. The population increased from 29 million in 1990 to approximately 44 million in 2020, reflecting a 69% rise. Such population growth must be accompanied by parallel economic growth to improve living standards, preserve natural resources, and secure the rights of future generations—key foundations of sustainable development. Among these essential resources, water emerges as a cornerstone of human life and economic progress. It plays a pivotal role as a vital input for the industrial and agricultural sectors. In Algeria, annual freshwater withdrawals grew from 2 billion cubic meters in 1980 to 9.8 billion cubic meters by 2020, according to World Bank statistics, with the agricultural sector accounting for approximately 63% of these withdrawals.

This increasing demand for water is compounded by concurrent challenges such as the adverse impacts of climate change, which are particularly acute in countries south of the Mediterranean, and the dual effects of population growth, which can yield both positive and negative outcomes. In response, the Algerian state seeks to foster economic growth while optimizing natural resource utilization to achieve water security. This concept underscores the country's ability to ensure sufficient water resources for human needs and economic activities while enhancing per capita freshwater availability, thus contributing to sustainable development.

Study problem: The study's problem can be articulated through the following primary research question:

To what extent do population and economic growth impact annual freshwater withdrawals in the context of climate change?

Hypotheses: To address this research question, the study proposes the following hypotheses:

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

•Population growth is associated with increased freshwater withdrawals.

•Economic growth leads to higher annual freshwater withdrawals.

•Climate change negatively impacts freshwater resources.

Research Objectives: This study seeks to investigate the impact of population and economic growth on freshwater resources in Algeria within the context of climate change. It aims to highlight the critical importance of water resource preservation and to examine the interconnections between population growth, economic development, rising temperatures, and annual freshwater withdrawals.

Research Methodology: Given the nature of the topic and the research question, this study employs a descriptive approach to analyze statistical data pertaining to the study's variables. Furthermore, it adopts an econometric approach by developing a model to evaluate the impact of demographic, economic, and climatic changes on annual freshwater withdrawals in Algeria during the period 1990–2020.

Literature Review:

- **Study of Touitou & Al-Amin (2018):** This study examines the impact of climate change on water resources in Algeria by analyzing how rising temperatures and shifts in the amount and pattern of precipitation affect surface runoff, groundwater, and the frequency of extreme events such as droughts and floods. The authors show that Algerian water resources are highly vulnerable to these climatic changes, with serious implications for water security and for patterns of economic development that depend heavily on water-intensive sectors. They also review a range of adaptation options, including diversifying water sources through dam construction, expanding seawater desalination, and reusing treated wastewater, alongside improving water-use efficiency in both agriculture and urban areas. The study concludes that water concerns must be explicitly integrated into climate and development policies and that integrated water resources management needs to be strengthened to reduce climate-related risks. In doing so, it underscores the importance of long-term planning to ensure the sustainability of Algeria’s water resources (Mohammed & Al-Amin, 2018).

- **Study by Berhail, S (2019):** This study aimed to evaluate the impact of climate change on groundwater resources in Algeria, with a specific focus on the Tafna Basin, which covers an area of 7,245 square kilometers. The research analyzed time-series rainfall data and applied climatic drought indicators alongside statistical tests to investigate shifts in rainfall patterns. The findings revealed a decline in rainfall ranging from 8.21% to 38.85%, depending on the station, with an overall average decrease of 17.85%. Furthermore, the study identified a

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

significant reduction in groundwater recharge volumes post-1987, underscoring the severe degradation of groundwater resources as a consequence of climate change (Berhail, 2019).

- **Study by Stringer, L, et al (2021):** This study explored the effects of climate change on water security in global dryland regions, home to over two billion people. It assessed projected changes in water security across drylands worldwide through 2100. The findings highlighted that effective water management, the deployment of advanced technologies, and the modernization of infrastructure could provide practical solutions to address these challenges. The study underscored the critical need to integrate water security within the broader framework of sustainable development to ensure an equitable and inclusive approach that meets the needs of all populations, with a particular emphasis on arid regions (Stringer et al., 2021).

- **Study of Kedida & Boukhetala, (2021):** This study analyses the impact of economic growth and population growth on the environmental pressure arising from water consumption in Algeria over the period 1980–2019, using an autoregressive distributed lag (ARDL) model based on annual data. Total water consumption is treated as the dependent variable, while real gross domestic product and population size serve as the main explanatory variables. The findings reveal a significant positive effect of both economic expansion and demographic growth on water consumption and the associated environmental pressure in the short and long run, implying that the expansion of economic activity and the rise in population intensify stress on limited water resources. Moreover, the study demonstrates that the relationship between economic growth and environmental pressure does not conform to the inverted-U pattern predicted by the Environmental Kuznets Curve, as environmental pressure does not decline at higher income levels. On this basis, the authors recommend incorporating water-use efficiency into economic policy and adopting demand-management and conservation strategies to reconcile economic growth objectives with environmental sustainability (Kedida & Boukhetala, 2021).

- **Study by Molajou, A., Afshar, A., & Khosravi, M (2021):** This study explored the relationship between freshwater demand, energy, and food, focusing on key factors such as population growth, economic development, and urbanization. It highlighted the inadequacy of traditional resource management strategies, which were poorly integrated and led to conflicting outcomes and increased competition among the three sectors. Given the intensifying impacts of climate change, the study underscored the critical importance of the "water-energy-food nexus" concept to better understand the intricate interdependencies among these systems. The study proposed a novel model aimed at expanding the feasible

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

space of this nexus, after examining the intricate dynamics between water, energy, and food systems to develop sustainable solutions (Molajou et al., 2021).

- **Lounnas, S., and Bouchelaghem, A. (2025)** examined the impact of economic growth and water stress on per capita renewable freshwater availability in Algeria over the period 1990–2020 using the ARDL model. The results indicated that, in the short run, economic growth slightly reduces per capita freshwater resources. In the long run, both increasing water stress and rising GDP per capita were found to lower freshwater availability per person. The study highlighted the urgent need to improve water resource management and to explore alternative water sources in order to ensure sustainability (Lounnas & Bouchelaghem, 2025).

2. Study Data

2.1 Population Growth

Population growth is a demographic phenomenon that represents one of the most significant challenges facing humanity, particularly in countries where population growth outpaces economic development. This disparity creates barriers to sustainable economic progress. The term "population growth" refers to the increase in population over specific periods, driven by birth rates exceeding death rates. This growth is especially pronounced in developing countries (Graff & Bremner, 2014).

Such trends have profound implications for policies related to food provision, particularly in instances of rapid population increases. As a result, population growth becomes a critical factor in planning across various sectors, including economic, social, educational, and healthcare domains (UNFPA, 2014). In Algeria, the post-independence period has been marked by a population surge due to a significant rise in birth rates and a decline in mortality rates, largely driven by improvements in healthcare and living standards following independence (Oubbiche & Bouhoreira, 2024). Figure 1 illustrates the development of Algeria's population growth rate (%) from 1990 to 2020.

Figure 1: Development of the Population Growth Rate in Algeria (1990–2020)



Source: Prepared by the researchers based on World Bank data.

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

The table clearly shows that the population growth rate declined between 1990 and 2007, then experienced an upward trend until 2016, before beginning to decrease again. Population growth is strongly influenced by living conditions and the policies implemented by the state.

2.2 *Economic Growth*

Economic growth refers to a consistent rise in a country's overall output, demonstrating its capacity to supply a wide array of goods and services to its population. This growth is driven by increased production levels or higher per capita economic output, ultimately leading to improved living standards and better health conditions for the population. Economic growth also encompasses all quantitative changes in various productive capacities and the extent to which they are utilized (Soliyev & Ganiev, 2021). Furthermore, economic growth is regarded as one of the key quantitative indicators of economic development. It is typically defined as the continuous rise in income over time and is commonly measured through the growth rate of real GDP or per capita GDP (Ogunmuyiwa, 2011).

Figure 2: Development of Per Capita GDP Growth Rate in Algeria from 1990 to 2020.



Source: Prepared by the researchers based on World Bank data.

The figure illustrates the volatility of Algeria's economic growth rate, which is primarily driven by the country’s reliance on revenues from the hydrocarbons sector. This dependence creates a direct link to the global oil market and its price fluctuations.

2.3 *Temperature*

Climate change triggers various natural phenomena due to shifts in temperature and major weather patterns. These changes can result from natural causes, such as fluctuations in solar activity and volcanic eruptions, or from human-induced factors, including increased greenhouse gas emissions and deforestation (Fakana, 2020).

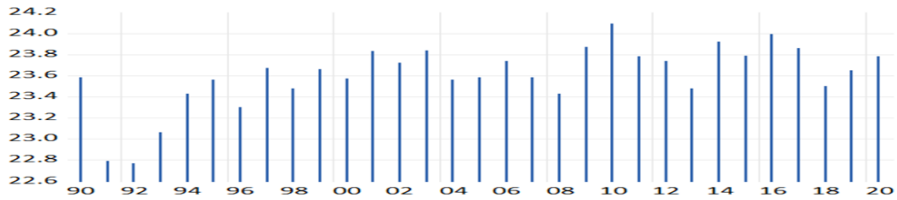
NASA defines climate change as a widespread global phenomenon primarily driven by the burning of fossil fuels, which release emissions into the atmosphere. Temperature, one of

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

the most critical climatic elements, is closely linked to atmospheric pressure, evaporation, and wind patterns (NASA, 2024).

Southern Europe is currently experiencing accelerated hydroclimatic changes. By 2050, air temperature is projected to rise by +2°C, extreme weather events are expected to become more frequent, river flows may decrease by up to 50%, and water reserves are anticipated to shrink due to reduced snowfall. Additionally, evapotranspiration and soil dryness will intensify, surface water temperatures will rise by +1.5°C, groundwater recharge will slow, and sea levels are projected to increase by up to 1 meter (UNEP/MAP, 2021).

Figure 3: Annual Average Temperature Changes (°C) in Algeria from 1990 to 2020.



Source: Prepared by the researchers based on World Bank data.

It is evident that temperatures exhibit instability, fluctuating between increases and decreases, as a result of global changes. These temperature variations are primarily driven by worldwide transformations, particularly the actions of major polluting countries and their adherence to UN recommendations aimed at reducing pollution to mitigate the negative impacts of climate change.

2.4 *Annual Freshwater Withdrawals*

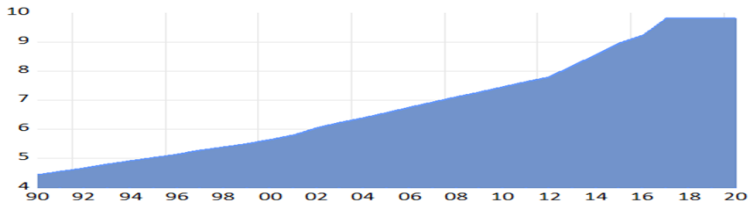
Countries strive to achieve water security, which refers to the continuous provision of water to meet both individual and economic development needs, while considering both quantity and quality. This also involves preserving existing water resources and identifying additional sources to keep pace with population and economic growth (Ragini & Saxena, 2025).

Water security can further be defined as the human right to access water, ensuring its availability in a safe and sufficient manner, at an affordable price, for various uses (UN CESCR, 2002). A country is considered to have water sufficiency if its per capita water share exceeds 1,700 m³. If the share falls between 1,000 m³ and 1,700 m³, the country experiences water stress. Countries with per capita water availability between 500 m³ and 1,000 m³ are classified as facing water scarcity, while those with less than 500 m³ per capita are considered to be experiencing absolute water scarcity (Falkenmark et al., 1989).

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

Additionally, the United Nations has included water in its urgent action plans to address climate change and its associated natural and environmental disasters, particularly concerning water resources. The UN has also adopted Sustainable Development Goal 6, which aims to "ensure availability and sustainable management of water and sanitation for all" by 2030. Achieving this goal requires significant policy actions from nations (UN DESA, 2024).

Figure 4: Development of Annual Freshwater Withdrawals (billion cubic meters) in Algeria from 1990 to 2020.



Source: Prepared by the researchers based on World Bank data.

It is evident that annual freshwater withdrawals have steadily increased from 1990 until 2017, after which they stabilized. This trend reflects the increasing strain on water resources in Algeria, exacerbated by the effects of climate change, which has caused over two decades of drought in the southern Mediterranean region. Furthermore, economic development and the increasing demand for natural resources to support population growth have further intensified this pressure.

3. Econometric Study on the Impact of Demographic, Economic, and Climatic Changes on Annual Freshwater Withdrawals in Algeria from 1990 to 2020:

3.1 Variables and Data Sources:

This study employed annual data covering the period from 1990 to 2020, with the timeframe chosen based on World Bank statistics (World Bank, 2025). Table 1 provides a detailed description of the variables, including their respective symbols and units of measurement.

Table 1: Data Sources and Description of Variables

Variables	Acronyms	Unit of Measurem	Source
Annual Freshwater Withdrawals	WAT	Billion cubic meters	World Bank
Economic Growth	PIB	%	
Temperature	TEMP	C°	
Population Growth	POP	%	

Source: Prepared by the researchers.

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

After defining the study variables, an econometric model will be constructed to examine the impact of temperature, population growth rate, and economic growth rate on annual freshwater withdrawals in Algeria during the study period. The proposed model is represented by the following equation:

WAT = f (PIB, TEMP, POP)

3.2 Study Methodology

To answer the research questions, this study utilizes the Autoregressive Distributed Lag (ARDL) model to develop an econometric framework. The ARDL model (Pesaran et al., 2001) is widely regarded as one of the most suitable methods for analyzing time series data characterized by non-stationarity. As outlined by Pesaran, Shin, and Smith (2001), The ARDL bounds testing approach can be used regardless of whether the variables are stationary at level I (0), integrated of order one I(1), or a mix of both. The only condition is that none of the variables are integrated of second order I (2). The ARDL model employed in this study to examine the short- and long-term impacts of the proposed independent variables on annual freshwater withdrawals is presented as follows:

$$\Delta WAT_t = a_0 + \sum_{i=1}^{p} a_{1i}\Delta \mathrm{WAT}_{t-i} + \sum_{i=0}^{q_1} a_{2i}\Delta \mathrm{PIB}_{t-i} + \sum_{i=0}^{q_2} a_{3i}\Delta \mathrm{POP}_{t-i} + \sum_{i=0}^{q_3} a_{4i}\Delta \mathrm{MET}_{t-i} +$$

$$b_1 \mathrm{WAT}_{t-i} + b_2 \mathrm{PIB}_{t-i} + b_3 \mathrm{POP}_{t-i} + b_4 \mathrm{MET}_{t-i} + \varepsilon_t$$

Where:

•Δ : presents first-order differences,

•p : Lag period for the dependent variable,

•q1, q2, q3 : Lag periods for the independent variables,

•b_1, b_2, b_3, b_4: Long-term relationship coefficients,

•a_{1i}, a_{2i}, a_{3i}, a_{4i}: Short-term relationship coefficients,

•a_0: Represents the constant term,

•ε_t: The stochastic error term.

To assess the presence of a cointegration relationship among the study variables, the bounds testing approach will be employed. This test is based on the following hypotheses:

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

$$H_0: b_1 = b_2 = b_3 = b_4 = 0$$

$$H_1: b_1 \neq b_2 \neq b_3 \neq b_3 \neq 0$$

Prior to constructing the ARDL model, it is essential to assess the degree of integration of the variables through unit root tests, such as the Augmented Dickey-Fuller (ADF) test. This step ensures that none of the variables are integrated of second order I(2), as this would violate the assumptions of the ARDL model. The ADF test is used to identify the presence and number of unit roots (if any) in the variables, utilizing three different models for this purpose.20:

1.Regression (without constant):$\Delta \boldsymbol{Y_t} = \gamma\, \boldsymbol{Y_{t-1}} + \sum_{j=1}^{p} \boldsymbol{\varphi_j} \Delta\, \boldsymbol{Y_{t-j}} + \boldsymbol{\varepsilon_t}$

2.Regression (with constant):$\Delta \boldsymbol{Y_t} = \boldsymbol{\alpha} + \gamma\, \boldsymbol{Y_{t-1}} + \sum_{j=1}^{p} \boldsymbol{\varphi_j} \Delta\, \boldsymbol{Y_{t-j}} + \boldsymbol{\varepsilon_t}$

3.Regression (with constant and time trend):$\Delta \boldsymbol{Y_t} = \boldsymbol{\alpha} + \boldsymbol{\beta t} + \gamma\, \boldsymbol{Y_{t-1}} + \sum_{j=1}^{p} \boldsymbol{\varphi_j} \Delta\, \boldsymbol{Y_{t-j}} + \boldsymbol{\varepsilon_t}$

- H_0: $\gamma = 0$: (Presence of a unit root),

- H1: $\gamma < 0$: (No unit root).

The ARDL model has gained considerable popularity in recent years as a robust method for analyzing cointegration relationships between economic variables. Introduced by Pesaran, Shin, and Smith (2001), the ARDL approach overcomes several limitations associated with traditional cointegration techniques, making it a pivotal tool for analyzing non-stationary time series data. This model accommodates the inclusion of multiple lags for both the dependent and independent variables, enabling the estimation of dynamic relationships.

Through this framework, the integrated relationship between variables is estimated, and long-term coefficients are derived. Cointegration is then tested using the Conditional Error Correction (CEC) mechanism within the bounds testing approach, relying on the F-statistic. This test determines whether the variables are cointegrated, with integration orders ranging between I (0) and I (1).

3.2 Discussion of Results:

Before constructing the ARDL model, it is essential to assess the degree of integration of the variables using unit root tests, such as the Augmented Dickey-Fuller (ADF) test. This step ensures that none of the variables are integrated of second order I(2), as the ARDL model

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

cannot be applied in such cases. If any variable is found to be I(2), alternative econometric methods must be used.

Table 02: Integration Degree of Time Series

Variable Symbol	Degree of Integration
WAT	**I(1)**
PIB	**I(1)**
TEMP	**I(0)**
POP	**I(0)**

Source: Prepared by the researchers based on EViews 12 outputs.

After verifying that none of the study variables are integrated of degree I (2), Appendix 01 details the process of selecting the optimal lag length for the ARDL model. This involved estimating the model with the maximum number of lags to preserve the maximum amount of information. The Akaike Information Criterion (AIC) was employed to determine the best-fitting model, which was identified as ARDL (4,3,3,4).

Subsequently, the Bounds Test was conducted to examine the presence of a cointegration relationship among the study variables. The results indicated that the computed F-statistic (7.00) exceeded the upper critical value at all significance levels. As a result, the null hypothesis of no cointegration was rejected, confirming the existence of a long-term cointegration relationship among the study variables.

Table 03: Results of the Bounds Tests

Fisher Statistic	**Value (7,00)**	**Numbers of Variables (04)**	**The Decision**
Critical Values of the Bounds			
Tabulated Values	**I (0)**	**I (1)**	We accept the hypothesis of a cointegration relationship between the study variables
10%	2.61	3.62	
5%	3.16	4.33	
1%	4.42	6.02	

Source: Prepared by the researchers based on EViews 12 outputs.

After confirming the existence of a long-term relationship among the study variables, we proceeded to evaluate the model's quality and performance to ensure it was free from any econometric issues. Table 04 provides a summary of the results from the diagnostic tests, with further details available in Appendix 02.

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

Table 04: Results of Diagnostic Tests

Statistical Test	Godfrey-Breusch Serial Correlation LM Test	Heteroskedasticity - Breusch Test Godfrey-Pagan	Bera - Jarque test normality	RESET Ramsey (Fisher)
Test Hypothesis	Autocorrelation Test of Residuals	Heteroscedasticity Test of Residuals	Normality Test of Residuals	Model Specification Test
Value (Probability)	0.15 (0.85)	1.38 (0.31)	0.21 (0.89)	2.01 (0.19)

Source: Prepared by the researchers based on EViews 12 outputs.

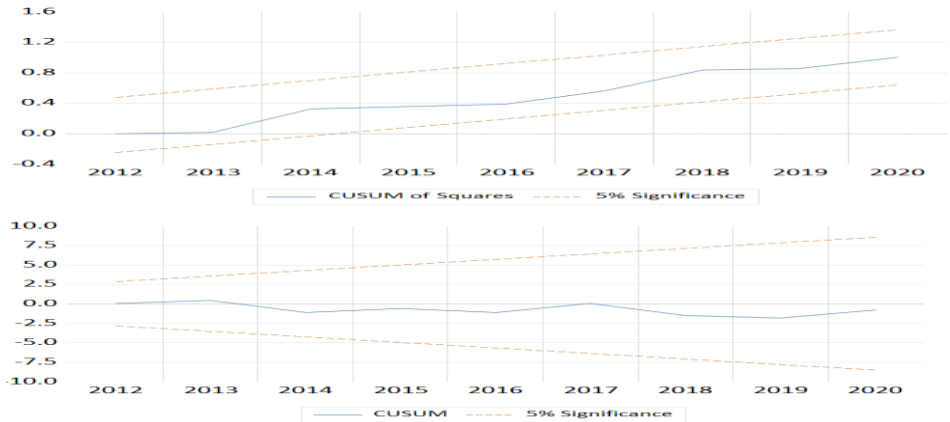
The results indicate that the model is free from serial autocorrelation, as confirmed by the Breusch-Godfrey test, which yielded a p-value of 0.85 for the Fisher statistic. This value exceeds the 5% significance level, supporting the null hypothesis of no autocorrelation.

In terms of heteroscedasticity, the Breusch-Pagan-Godfrey test suggests that the ARDL model is not affected by heteroscedasticity, with a p-value of 0.31, which is also greater than 5%.

Regarding the normality of the residuals, the Jarque-Bera test produced a p-value of 0.89, indicating that the residuals follow a normal distribution.

Finally, the Ramsey RESET test revealed no specification issues with the model, with a p-value of 0.19, confirming that the model is free from econometric problems and that its results are reliable.

Figure 5: Results of Structural Stability Test of Model Parameters.



Source: Prepared by the researchers based on EViews 12 outputs.

The graphical representation in Figure 1, displaying the cumulative sum of residuals (CUSUM) and the cumulative sum of squared residuals (CUSUM of squares), shows that the statistical values remain within the critical bounds. This indicates stability and consistency

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

between the short-term and long-term results. Therefore, the model is free from any structural changes.

Having obtained these results through various tests, including assessments of stability and the existence of a long-term relationship, we will now proceed to measure the relationships in both the short-term and long-term using the ARDL methodology.

Table 05: Results of Model Diagnostics

Short-term Model Coefficients			
Variable	**Parameter**	**T-Statistic**	**Probability**
D(PIB)	**0.01**	**-0.96**	**0.35**
D(TEMP)	**0.47**	**6.59**	**0.0001**
D(POP)	**0.32**	**-1.10**	**0.29**
COINTEQ (-1)	**-0.31**	**-7.11**	**0.0001**
Long-term Model Coefficients			
PIB	**0.31**	**1.62**	**0.13**
TEMP	**4.23**	**8.01**	**0.0000**
POP	**3.97**	**3.76**	**0.0044**

Source: Prepared by the researchers based on EViews 12 outputs.

Based on the results in Table 05, we observe a positive and statistically significant relationship between temperature (TEMP) and annual freshwater withdrawals (WAT) in Algeria in the short term (period t). Specifically, a one-unit increase in temperature leads to an increase of 0.47 units in freshwater withdrawals. While both economic growth and population growth exhibit impacts on freshwater withdrawals, these effects are not statistically significant.

The error correction coefficient is statistically significant and negative, confirming the presence of an effective error correction mechanism, consistent with economic measurement theory. This statistic indicates the speed at which the model adjusts from short-term deviations to the long-term equilibrium. The deviation of the dependent variable from its equilibrium value in period t-1 is corrected by 31% in period t, which represents a reasonable adjustment.

In the long term, the economic relationship between the dependent and explanatory variables is represented by the following equation:

WAT = 4.2374 * TEMP + 3.9755 * POP + 0.3160 * PIB - 101.2086

The results show that temperature (TEMP) and population growth (POP) have a positive and statistically significant impact on annual freshwater withdrawals (WAT) in Algeria in the

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

long term. Specifically, for every one-unit increase in temperature, freshwater withdrawals increase by 4.23 units, and for every one-unit increase in population growth, freshwater withdrawals increase by 3.97 units. Although economic growth has an effect on freshwater withdrawals, it is not statistically significant.

These results underscore the influence of climate change, which has caused reduced rainfall and prolonged droughts in Algeria, as well as the impact of population growth. However, the effect of economic growth does not show statistical significance. The intercept term captures the influence of unaccounted variables, such as the role of water resource management in preserving water through alternative sources like seawater desalination, as well as increasing investments in sustainable water resources.

4. *CONCLUSION*

The provision of water resources for both the economic sector and domestic use is essential and serves as a key driver for development. It is noteworthy that Algeria has experienced a decline in per capita renewable freshwater resources, from 440.74 m^3 in 1990 to 258.83 m^3 in 2020, according to World Bank statistics. This reduction occurred alongside population growth, from 29 million in 1990 to approximately 44 million in 2020. The study examined the effects of population growth, economic growth, and climate change, as indicated by the average temperature, on annual freshwater withdrawals in Algeria from 1990 to 2020, utilizing the ARDL model. The findings are as follows:

Temperature (TEMP) has a positive and statistically significant impact on annual freshwater withdrawals in the short term. Specifically, a one-unit increase in temperature results in a 0.47-unit increase in freshwater withdrawals.

In the long term, both temperature (TEMP) and population growth (POP) exert positive and statistically significant effects on annual freshwater withdrawals. Specifically:

A one-unit increase in temperature leads to a 4.23-unit increase in freshwater withdrawals.

A one-unit increase in population growth results in a 3.97-unit increase in freshwater withdrawals.

The influence of demographic and climatic changes on water resources underscores the need for policies focused on ensuring sustainable water security. This includes exploring sustainable alternatives such as seawater desalination, a critical solution given Algeria's

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

extensive coastline of over 1200 km. It is also essential to draw lessons from countries that are leaders in desalination technology to reduce costs and improve efficiency.

5. *Bibliography List*:

1. *Journal article*:

- Berhail, S. (2019), The impact of climate change on groundwater resources in northwestern Algeria. Arabian Journal of Geosciences, 12(24), 770.
- Fakana, S. T. (2020). Causes of climate change: Review article. Global Journal of Science Frontier Research: (H) Environment & Earth Science, 20(2), 1–8.
- Falkenmark, M., Lundqvist, J., & Widstrand, C. (1989). Macro-scale water scarcity requires micro-scale approaches. Natural Resources Forum, 13(4), 258–267.
- Kedida, A., & Boukhetala, S. (2021). The effect of economic growth on the environmental pressure of water consumption in Algeria: Using autoregressive distributed lag analysis for the period (1980–2019). Khazzartech Journal of Industrial Economics, 11(1), 730–744.
- Lounnas, S & bouchelaghem, A. (2025). Assessing the Impact of Economic Growth and Water Stress on Per Capita Freshwater Availability: An Econometric Analysis of Algeria (1990–2020), Finance and Business Economics Review, Vol.9, No. 1, pp. 114-126.
- Mohammed, T., & Al-Amin, A. Q. (2018). Climate change and water resources in Algeria: Vulnerability, impact and adaptation strategy. Economic and Environmental Studies, 18(1), 411–429.
- Molajou, A., Afshar, A., Khosravi, M., Soleimanian, E., Vahabzadeh, M., & Varina, H. A. (2021), A new paradigm of water, food, and energy nexus. Environmental Science and Pollution Research, 1-11.
- Ogunmuyiwa, M. S. (2011). Does external debt promote economic growth in Nigeria? Current Research Journal of Economic Theory, 3(1), 29–35.
- Oubbiche, S., & Bouhoreira, A. (2024). The impact of the population problem on school dropout in Algeria. International Journal of Early Childhood Special Education (INT-JECSE), 16(4), 483–493.
- Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. Journal of applied econometrics, 16(3), 289-326.
- Ragini, & Saxena, S. (2025). Water security – A need of 21st century. International Journal of Environmental and Ecology Research, 7(1), 4–12.
- Soliyev, I. I., & Ganiev, B. B. (2021). Key factors influencing economic development. European Journal of Research Development and Sustainability (EJRDS), 2(3), 12–16.

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

- Stringer, L. C., Mirzabaev, A., Benjaminsen, T. A., Harris, R. M., Jafari, M., Lissner, T. K., & Tirado-von Der Pahlen, C. (2021), Climate change impacts on water security in global drylands. One Earth, 4(6), 851-864.

2. *Internet websites*:

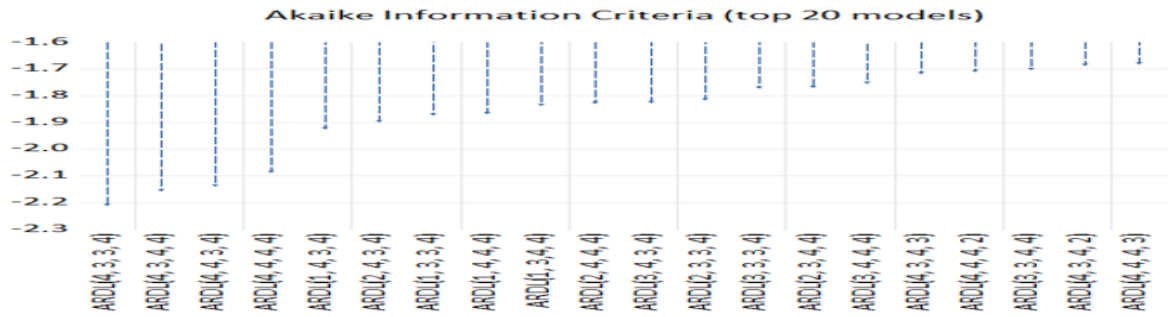
- Department of Economic and Social Affairs (DESA). (2024). Water and sanitation. United Nations Sustainable Development Goals. Retrieved November 7, 2025, from https://sdgs.un.org/topics/water-and-sanitation
- Graff, M., & Bremner, J. (2014). A Practical Guide to Population and Development. Washington, DC: Population Reference Bureau. Retrieved from https://www.prb.org/wp-content/uploads/2021/07/guide-population-development.pdf
- NASA. (2024.). What is climate change? NASA Global Climate Change. Retrieved November 9, 2025, from https://science.nasa.gov/climate-change/what-is-climate-change/
- UN Committee on Economic, Social and Cultural Rights. (2002). General Comment No. 15: The right to water (Arts. 11 and 12 of the International Covenant on Economic, Social and Cultural Rights). U.N. Doc. E/C.12/2002/11. Retrieved November 12, 2025, from https://www.globalhealthrights.org/instrument/cescr-general-comment-no-15-the-right-to-water/
- UNEP/MAP. (2021). Climate change in the Mediterranean. United Nations Environment Programme / Mediterranean Action Plan. Retrieved November 3, 2025, from https://www.unep.org/unepmap/resources/factsheets/climate-change
- United Nations, Department of Economic and Social Affairs, Population Division. (2022). World Population Prospects 2022: Summary of Results (UN DESA/POP/2022/TR/NO. 3). New York: United Nations. Retrieved November 13, 2025, from https://vert.eco/wp-content/uploads/2022/07/wpp2022_summary_of_results.pdf
- UNFPA. (2014). Population dynamics and policies. United Nations Population Fund. Retrieved November 4, 2025, from https://www.unfpa.org/resources/population-dynamics-and-policies
- https://data.worldbank.org, Retrieved November 2, 2025, from

https://data.worldbank.org/indicator/ER.H2O.FWDM.ZS?end=2020&locations=DZ&start=1961

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)

5. *Appendices:*

Appendix (01): Results of Lag Selection for the ARDL Model



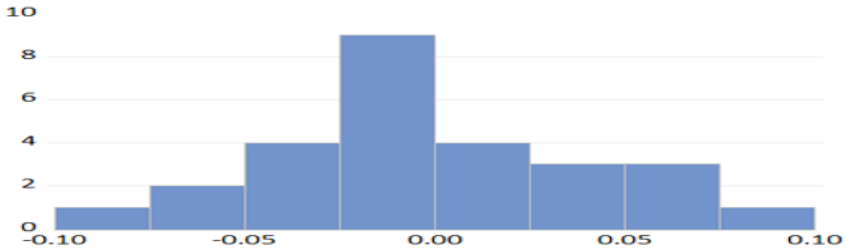
Appendix (02): Diagnostic Results of ARDL Model Tests

Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

F-statistic	1.384986	Prob. F(17,9)	0.3166
Obs*R-squared	19.53336	Prob. Chi-Square(17)	0.2988
Scaled explained SS	1.732291	Prob. Chi-Square(17)	1.0000

Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 2 lags

F-statistic	0.154383	Prob. F(2,7)	0.8598
Obs*R-squared	1.140640	Prob. Chi-Square(2)	0.5653



Series: Residuals
Sample 1994 2020
Observations 27

Mean	-5.53e-15
Median	-0.003567
Maximum	0.090108
Minimum	-0.076537
Std. Dev.	0.041968
Skewness	0.090013
Kurtosis	2.596307
Jarque-Bera	0.219800
Probability	0.895924

Ramsey RESET Test
Equation: UNTITLED
Omitted Variables: Squares of fitted values
Specification: WAT WAT(-1) WAT(-2) WAT(-3) WAT(-4) TEMP TEMP(-1) TEMP(-2) TEMP(-3) POP POP(-1) POP(-2) POP(-3) PIB PIB(-1) PIB(-2) PIB(-3) PIB(-4) C

	Value	df	Probability
t-statistic	1.420305	8	0.1933
F-statistic	2.017267	(1, 8)	0.1933
Likelihood ratio	6.071457	1	0.0137

Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International (CC BY-NC-ND 4.0)