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The effect of economic growth on the environmental pressure of water consumption in Algeria. Using autoregressive distributed LAG analysis for the period (1980-2019)

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Abstract:
This paper aims to try to investigate the impact of economic growth on the environmental pressure of water consumption within the framework of the Kuznets environmental curve in Algeria, both in the short and long term, by conducting a formal study in Algeria during the period 1980-2019, The ARDL self-regression methodology was used to verify this study using variable the water consumption as a dependent variable and explanatory variables represented in real GDP and the population..
Based on the study variables, the study found that growth positively affects the environmental pressure of Algeria's water consumption in the short and long terms. This is different from the assumptions of Kuznets environmental curve.

Keywords:
Economic growth;
Environmental pressure;
Water Consumption;
ARDL model;
Kuznets Environmental Curve.

JEL Classification Codes: E01, Q25, Q53.

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1. INTRODUCTION

Economic growth is one of the central goals that countries seek to achieve to raise society's living standards in all its aspects. To achieve this goal, real GDP needs to be increased as a measure or indicator of economic growth. As this is the case, increasing GDP requires expanding the use of the production inputs of available economic and natural resources from which it is available. This expansion of input use produces different environmental problems. Economic growth and population growth may, on the other hand, generate environmental pressure on available water resources to meet the needs of agricultural, domestic, industrial, and other sectors. To expand production to meet the demand of individuals for goods and services is driving the trend of depleting water resources beyond the safe limit for this critical source of water, given the limited supply of such resources.

Due to the nature of the interrelation between economic activities on the one hand and the environment, on the other hand, this study is based on the so-called Kuznets Curve, and this curve is attributed to the economist Simon Kuznets through his analysis of the relationship between economic growth and income inequality, and since the beginning of the nineties of the last century has taken The Kuznets Curve is a different framework in which the environmental dimension was included and became known as the Environmental Kuznets Curve (EKC).

The study problem can be summarized in the following central question: What is the impact of economic growth on water consumption's environmental pressure within the Environmental Kuznets Curve in Algeria during 1980-2019? This study's important in clarifying the effect between economic growth and the environmental index of environmental pressure on water consumption and verifying that the model aligns with the EKC curve assumptions. As he tries to explain this situation in Algeria. To answer the problem presented and the focus of this study, the descriptive approach to environmental pollution has been based on water pollution and its relationship to economic growth, as well as the standard process using the distributed time-lapse Self-regression (ARDL) model to answer the problem, presented and tested the validity of the hypothesis presented.

2. Literature Review

Among the studies that have dealt with this topic:

- The study of Thompson "Water Abundance and EKC of Water Pollution".

This study aimed to compare poor and abundant countries in water. This paper contributes to the literature published on the Environmental Kuznets Curve (EKC) by determining the effect of water availability on the EKC of water pollution. By using the method of multiple linear regression for areas of the abundance of water between countries. The results indicate that water abundance significantly influences the EKC tipping point. (Thompson, Water abundance and an EKC for water, 2012)

- The study of Thompson & Jeffords "Virtual Water and an EKC for Water".

The two researchers tried, through this study, to find out the extent to which the Environmental Kuznets Curve (EKC) was achieved for water pollution at the level of the United States of America. Hence, hypothetical water data, which means the total amount of water needed to produce a commodity, was used throughout production. On the other hand, the water independence index was adopted, which is defined as the water required of local output divided by the amount of water necessary for all imported commodities. The two researchers found increased trade openness and the import of water-intensive items may reduce water pollution levels. (Thompson & Jeffords, Virtual Water and an EKC for Water, 2016)

- Sun & Fang research research "Water use pattern analysis: a non-parametric approach for the identification of the Kuznets environmental curve".

The two researchers attempted to explain the relationship between water usage and economic growth in this analysis, using the Kuznets environmental curve. For these purposes, the Mann-Kendall method was used by the researchers to treat the discovery of an inverted U-shape based on a non-standard approach, where the values of the study statistics are calculated, depending on the size of the results, using the depletion method, the approximation method or the analytical method. Since the non-laboratory presentation approach is compatible with the Kuznets environmental curve irrespective of its original or logarithmic form of the data used, the environmental Kuznets curve has been successfully used to detect trends in the actual usage of water in China and some neighboring countries. (Sun & Fang, 2018)

- The research by Hao et al "On the link between water use and economic growth in China: new evidence from a simultaneous review of the equation model".

The researchers decided to study the relationship between water and economic growth in China in the Environmental Kuznets Curve (EKC). Panel data was used for 29. Province in China from 1999-2014. To research the dual causality between water usage and economic growth, the relationship was calculated using a standard polynomial model and a simultaneous equation model for analysis (SEM) while assessing the overall effects of socio-economic factors, including industrial structure, population size, openness to trade and the number of local water supplies. Finally, overall and sector water usage is tested. Among the study results, the relationship between per capita water consumption and per capita GDP is found in the form of the letter "N." On the other hand, there is evidence of the positive contribution to the economic growth of industrial water usage, while the effects of total and non-industrial water use on per capita production are non-linear in the domestic gross; commercial openness and per capita water supplies are positively associated with water consumption and the rise in population density would lead to an increase in density. (Hao, Hu, & Chen, 2019)

We conclude that economic growth and water use are related through these studies, considering the importance of water supplies in economic development, forecasting future water demand, and establishing response strategies.

3. Theoretical part

Water is considered contaminated when its elements change the composition or change the state of its features directly or indirectly. Water shortages and usability are problems in dry areas and wet areas; therefore, the study is an attempt to highlight the impact of economic growth on environmental pressure on water consumption, as it is GDP that is the one that crosses economic growth.

3.1 Environmental pressure for water consumption

To highlight the environmental pressure of water consumption that has become a concern of countries in the water market. While environmental pressure is reflected in the amount of water consumed. Increasing the population requires expanding production to meet the demand of individuals for goods and services. Water is also a resource that will be increasingly demanded by the economy's constituent sectors, such as the domestic, industrial, agricultural, and even service sectors, and increasing demand for domestic use. Growing demand for water consumption will generate environmental pressure on water resources with limited supply.

3.1.1 Environmental pressure for water consumption in the world

Water covers about 71 percent of the earth's surface and is measured to be about 296 million cubic miles, and 98 percent of it is in a liquid state. Studies show that because of its salinity and the remainder of about 03 percent fresh water, about 97 percent of the world's water is not suitable for use. Still, it is not much accessible because a large part of it is either present. (USGS, 2020)

3.1.2 Environmental pressure of water consumption in Algeria

The nature and movement of water consumption in Algeria can be known through data provided by the Food and Agriculture Organization of the United Nations (FAO), which shows that there is a marked increase in the amount of water withdrawn for consumption, as the value of total water consumption in Algeria has reached its most significant value. In 2019, the equivalent of 10.46 billion square meters, as shown in Figure 1, where water consumption for agricultural purposes constituted the highest percentage, equivalent to 63.78%, followed by domestic use, at 34.42%, and finally 1.826% for industrial purposes at the limits of environmental flow requirements It is estimated at 4.56 billion square meters for that year. That is, the two primary users of water in Algeria are the agricultural and household sectors, but the share of the farming sector is increasingly declining in the face of competition resulting from the supply of drinking water and the increase in the number of homes connected to a public drinking water network. (O.N.S, 2006, p. 14)

3.2 Economic growth

Economic growth is one of the critical goals pursued by governments and by people's ambitions, as it represents the material sum of the economic and non-economic activities undertaken in society, as it is one of the required conditions for improving the standard of living of organizations and a measure of their prosperity.

3.2.1 Economic growth definition

The definitions of economic growth differed among many economists. He defined the economist Kuznets described economic growth as essentially a quantitative phenomenon; Thus, a country's economic growth can be determined by the continuous increase of population and per capita product (Bénichi & Nouschi, 1990, p. 44).

3.2.2 Economic growth in Algeria

To studying economic growth in Algeria, based on the data of the World Bank, it is noted that the GDP in Algeria is increasing during the study period, which suggests that the state pursues a policy to boost economic growth and get out of economic crises through programs Systematic correctional facility.

3.3 Environmental Kuznets Curve Assumptions

Most of the studies in this field are based on the so-called Kuznets Curve. This curve is attributed to the economist Simon Kuznets's analysis of the relationship between economic growth and income inequality. When the assumption is that when the level of income is low, then with the increase in revenue, income inequality increases until it reaches a certain point. Then the disparity begins to decrease with the increase in income (Kuznets , 1955). From the nineties of the last century, the Kuznets curve's relationship took a different framework in which the environmental dimension was included and became known as the (Environmental Kuznets Curve) (EKC).

For the shape of the relationship that the Kuznets curve takes, several theories have been presented. When the economy achieves a sufficiently high standard of living, people begin to give environmental facilities an increasing value. Therefore, after income reaches a certain level, the desire to pay for a clean environment increases by a higher income percentage as an explanation. First, when the structure of the economy changes from a ruin, environmental degradation tends to increase. As for the third explanation, when the state is rich, it can spend more on research and development. Technological progress is accompanied by economic growth, and unclean technology is replaced by new environmentally sound technologies, which ultimately improve the quality of the environment and, as a fourth explanation, political system forms or specific cultural values play an essential role in the implication of environmental discounts. (Kijima, Nishide, & Ohyama, 2010)

4. Data and methodology

Formally, in the majority of studies, the basic EKC equation that is estimated is of the following form:

$$E_{it} = (\alpha + \beta_i F_i) + \delta Y_{it} + \emptyset (Y_{it})^2 + K_t + \varepsilon_{it} \quad \ldots\ldots (01)$$

Where E denotes the environmental indicator, either in per capita form or in the form of concentrations, Y denotes per capita income, F denotes country-specific effects, k refers to year specific dummies or a linear time trend and i and t refer to country and year, respectively. In equation (01), if δ is negative and statistically significant but ϕ is statistically insignificant, then we get pattern A. These are indicators that show an unambiguous improvement with rising per capita income, such as access to clean water and adequate sanitation. If δ is positive and statistically significant but ϕ is statistically insignificant, then we get pattern C. These are indicators that show an unambiguous deterioration as incomes increase (Van Alstine & Neumayer, 2010).

This study relied on the Kuznets environmental model to explain economic growth's effect on the environmental pressure of water consumption in Algeria during the period from 1980 to 2019. We have relied on World Bank data fo … (02) d population data. Simultaneously, the total water consumption variable is taken from the United Nations Food and Agriculture Organization (FAO) database, where the data covered the period of the study (1980-2019). As it takes the form of the following equation:

$$\mathrm{Ln\,WQ} = \beta_0 + \beta_1\,\mathrm{Ln(GDP)} + \beta_2\mathrm{Ln(GDP)}^2 + \beta_3\,\mathrm{Ln(POP)} + \varepsilon$$

Where: LnWQ represents the environmental pressure indicator for water consumption (total water consumption); Ln (GDP) expresses Economic Growth (GDP); Ln (POP) means population.

Equation (02) is tested to test the forms of realization of the environmental Kuznets hypothesis expressing the relationship between economic growth and environmental pressure of water consumption according to parameters β_1, β_2, and β_3, which are long-term elasticity's of total water consumption with GDP, and with the square of GDP Total, and with the population respectively. According to the environmental Kuznets curve hypotheses, the β_1 signal is expected to be positive, while the β_2 signal is expected to be harmful, and the β_3 signal is expected to be positive.

To study the compatibility of the model's hypotheses in Algeria, the following variables were used:

- The dependent variable expressing the environmental pressure of water consumption: it is the total water consumption, expressed in billion cubic meters per year, denoted by the symbol WQ;

- The interpreted variable expressing economic growth: it is GDP expressed in constant prices of the US dollar in 2010, symbolized by GDP;

- The variable explained by the control is taken from the population, denoted by the symbol POP.

5. Results and discussion

5.1 Analysis of the variables

This study is an annual time series of variables for the period between 1980 and 2019 and is expressed in its logarithmic form in the following table:

Table 1. Descriptive statistics

	LnWQ	LnGDP	lnGDP²	LnPOP
Mean	1.662632	25.52001	651.3586	17.24133
Median	1.624285	25.44247	647.3197	17.25741
Maximum	2.347558	26.02753	677.4321	17.55860
Minimum	1.252763	25.11647	630.8372	16.86487
Std. Dev.	0.319027	0.300787	15.38122	0.192324
Observations	40	40	40	40

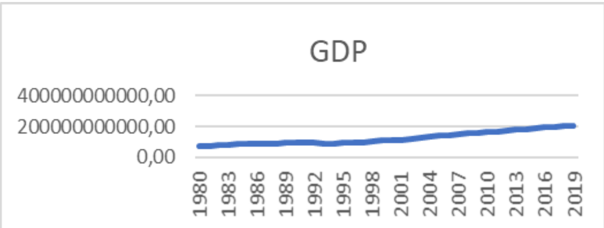
Source: Prepared by the researchers, based on outputs of Eviews 11.

Table 1 summarizes various descriptive statistics of the following study variables:

5.1.1 Gross domestic product (GDP)

Through figure 1, we notice that the GDP has evolved since 1980 to reach in 2008 about 6.4607E + 12 $, as it decreased in 2009 and then started to increase from 2010 to 2016, and the main driver of growth was the recovery of the oil and gas sector in 2014, it continued to rise, but in weakest proportions. In 2017, the economy contracted by 0.4% due to the contraction of the oil sector. Considering the full 2019, GDP grew 0.7%, down from 1.4% in 2018 (LAMRI & TAIBI, 2020, p. 57). So, we can say the value of GDP continues to increase throughout the study period, but at varying rates due to fluctuations in oil prices and reforms under Algeria's IMF conventions and development programs.

Figure 1. GDP development in Algeria (1980-2019)

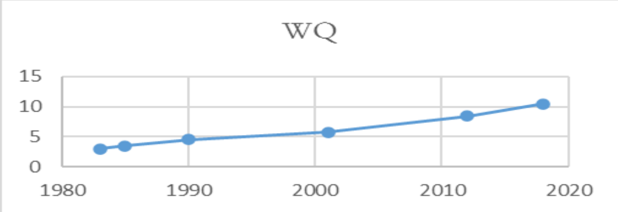


Source: The achievement of researchers based on World Bank data.

5.1.2 Evolution of total water consumption (WQ)

It is noticed through Figure 2 a continuous increase in total water consumption in Algeria, as it was estimated in 1980 at approximately 3 billion cubic meters per year, to rise to 10.46 billion cubic meters in 2019, meaning that it increased Three times due to the increase in the population, on the one hand, the rise in land use, and the traditional irrigation processes in the agricultural and industrial production process alike, which is illustrated in the following figure:

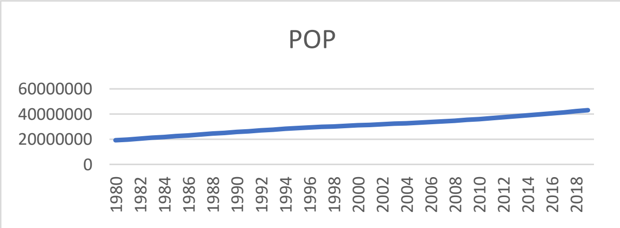
Figure 2. Water consumption development (1980-2019)



Source: The achievement of researchers based data from FAO.

5.1.3 Population growth (POP)

Figure 3. population (1980-2019)



Source: The achievement of researchers based on World Bank data.

Figure 3 shows that Algeria's population doubled from 19 million in 1980 to more than 43 million, highlighting the extent to which health care for children and mothers has increased and improved social welfare and income for Algerian families.

5.2 Self-regression model for distributed time gaps (ARDL)

After the study and the theoretical analysis, as well as the descriptive process of the development of the various study variables, the standard analysis of the long-term relationship, will be based on the ARDL model, which is characterized by that it can be applied in the case of study variables stable at the level of integrated at the first degree or even A mixture of the two together; Being one of the most suitable models in small samples; The capabilities of this model are efficient and unbiased. It helps to eliminate the problem of deleting the variables and the issue of self-correlation; Through this model, it is possible to estimate long and short-term relationships in one equation (Emeka & Kelvinuko, 2016).

The ARDL model based on the UECM model and the ARDL Bound Testing Approach proposed by "Pesaran" is the most suitable for detecting the existence of the covariates between the model variables (Pesaran, Shin , & Smith, 2001), where the cointegration test is performed by estimating the UECM model with the following formula:

$$\Delta LnWQ = C + \sum_{i=1}^{K1} \propto_{1i} \Delta LnWQ_{t-i} + \sum_{i=0}^{K2} \beta_{1i} \Delta LnGDP_{t-i} + \sum_{i=0}^{K3} \beta_{2i} \Delta \, Ln \, \Delta lnGDP_{t-1}^{2}$$
$$+ \sum_{i=0}^{K4} \beta_{3i} \Delta LnPOP_{t-i} + \delta_1 LnWQ_{t-i} + \delta_2 LnGDP_{t-i} + \delta_3 Ln \, \Delta lnGDP_{t-1}^{2}$$
$$+ \delta_4 LnPOP_{t-i} + \varepsilon_{1t} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (03)$$

Where: C represents the constant term; Δ represents variances of the first degree; Ln represents the Napierian logarithm; k1 represents the slowdown period of the dependent variable WQ; k2, k3, k4 represents the slowdown times for the interpreted variables GDP, GDP^2, POP; Represent α_{1i}, β_{1i}, …, β_{3i}: coefficients of short-term relationships; They represent: δ_1 ..., δ_4: long-term relationship transactions; ε_{1t} is the random error term.

To implement this model, it is necessary to go through the following stages: first, testing the stability of the time series, then determining the slowdown periods before estimating the model, followed by the process of diagnosing the residuals of the estimated model through the sequential correlation of the residuals and the variance of the variance and testing the stability of the model and finally testing the co-integration to add to all these tests a causal relationship test to highlight Impact between variables.

5.3 Stationarity test

This test aims to avoid multicollinearity between independent and dependent variables resulting from the non-stationarity of the variables in estimating the standard model.) using Eviews 11 on all model series. The results are shown in Table 2 indicate that the model variables represented in LnWQ, LnGDP, and $LnGDP^2$ are not stable at the level and have become stable when using the first difference, as the calculated values were more significant than the tabulated values that are, they became integrated into a degree I (1) At the level of significance of 5%, while the LnPOP series was integrated from grade I (0).

Table 2. Stationarity test using ADF

	At level			First difference			Cointegration
	None	Intercept	Int.& trend	None	Intercept	Int.& trend	
T.terace5%	-1.95	-2.94	-3.54	-1.95	-2.95	-3.54	
LnWQ	2.00	0.08	-2.45	-5.74	-6.41	-6.74	I(1)
LnGDP	2.80	0.89	-2.33	-2.46	-3.86	-4.19	I(1)
LnGDP2	2.80	0.93	-2.33	-2.43	-3.83	-4.18	I(1)
LnPOP	3.00	-3.77	-3.87	-1.34	-3.56	-2.95	I(0)

Source: Prepared by the researchers, based on outputs of Eviews 11.

5.4 Time lag testing and model estimation

Before performing the selection and estimation process, the ARDL path delay must be determined, depending on the two criteria (Akaike and Schwarz). With the help of Eviews11, it was found that the number of time gaps forms the ARDL model (3,3,3,2) through the Appendice 1 meaning that the dependent variable represented in total water consumption has three degrees of lag, along with the explained variables, both the gross domestic product and the square of the gross domestic product. As for the population, it is only two degrees of delay in their logarithmic form. Appendice 2 summarizes the self-regression estimation results for the distributed time gaps of the ARDL rank (3,3,3,2), assuming that the maximum delay is 3.

5.5 Model validity test

It is noticed through the results of the diagnostic tests for the models listed in the following tables no 3 and no 4:

Table 3. Breusch-Pagan-Godfrey

Test Statistic	t.statistic	P.value
F-statistic	1.72	0.18
Obs*R-squared	5.01	0.17

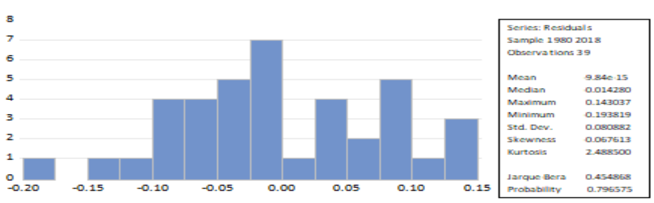
Table 4. Breusch-Godfrey

Test Statistic	t.statistic	P.value
F-statistic	4.14	0.12
Obs*R-squared	7.79	0.32

Source: Prepared by the researchers, based on outputs of Eviews 11

These tables respectively that these models do not suffer from the problem of self-correlation of errors using (Breusch-Godfrey Serial Test). The model does not contain a crisis of heterogeneity errors using the Breusch-Pagan-Godfrey Test.

Figure 4. Test Jarque-Bera



Source: The achievement of researchers based on Eviews 11.

As for the test for the normal distribution of residues, shown in Figure 4, it is clear that the residues have a normal distribution (Test de Jarque-Bera Test).

5.6 Cointegration test

This test is done through the Johançon Cointegration Test, whose results appear in Appendice 3, shows that the trace statistic values are more significant than the critical values at a significance level of 5%, and this is evidence of the existence of a long-term cointegrate relationship between the independent variables and the dependent variable.

5.7 Granger causality test

The findings shown in Table 5 show that, when applying the Granger causality test, the estimated value of the Fisher statistics is greater than the tabulated value for examining the causal relationship between the gross domestic product and the GDP square and the total water consumption population. This implies that the explained variables have a direct influence on the dependent variable in the short term, referring to the results obtained in the calculated multiple linear regression model, and this is shown in the following table:

Table 5. Granger causality

Trend	F.statistics	P.value	Causality
LnGDP → LnWQ	2.54	1.39	Cause
LnGDP2 → LnWQ	2.56	1.39	Cause
LnPOP → LnWQ	6.23	1.39	Cause

Source: Prepared by the researchers, based on outputs of Eviews 11.

5.8 Estimation outputs of model

The results of this study in the short and long terms can be interpreted as follows:

5.8.1 Short-term model estimation results

In the short time, Table 6 shows the approximate model formula, where the calculated probability value of all variables explained is less than 0.05, and where the variables defined in this model are significant. Besides, changes in the explained variables listed in the model account for 93 percent of changes in the dependent variable, and errors account for 7 percent of the dependent variable changes. The model has a very high explanatory ability, in general.

Table 6. Wald test

Variables	parameters	St (tc)	Prob	P	R2	DW	SCR
Constant β_0	651.04	3.83	0.0006	145.58	0.93	1.15	0.24
LnGDP	52.73	3.94	0.0004				
lnGDP^2	1.03	3.98	0.0004				
LnPOP	1.27	4.87	0.000				

Source: Prepared by the researchers, based on outputs of Eviews 11.

The value of the variable GDP was positive, which means that the relationship between GDP and the total consumption of water is expelled, the higher the gross GDP per unit, the higher the water consumed by 52.73 units, i.e., in the case of Algeria, with the increase in the gross domestic product, the increase in the water finished increases and does not decrease. 1.03 units, which is contrary to the Kuznets hypothesis that the low level of environmental pressure on water resources in the early stages of economic growth will not continue as it is in the later stages of development, where the supplier's response is unable to reduce environmental pressure, hence this pressure will increase in the advanced stages of growth that the Algerian economy is going through because the occurrence of such a situation is due to the limited resource and lack of the population change, the signal was also positive, which means a direct relationship between the increase in population and the total water consumed, which is identical to what was expected.

5.8.2 The estimation results of the long-term model

From Appendice 1 and 2, it is clear that the GDP and the square of the GDP have a significant effect in the long term, in contrast to the population variable; that was found to be insignificant in a long time. It is also evident from the assessment results that the environmental pressure model for water consumption does not comply with the EKC curve's assumptions, which indicates that the economy is exposed to environmental degradation in the early stages of economic growth. Then the quality of the environment improves after a subsequent period of transition. In this model, with the increase in economic growth, the environmental pressure will increase continuously, in contrast to the environmental improvement according to the EKC curve's assumptions. This indicates that the EKC curve's shape depends on the type of environmental pressure the economy is undergoing. There are environmental pressures that lead to improvement after a period of economic growth due to the possibility of dealing with and treating them as in the case of CO_2 emissions, so they take the form of an EKC curve (this is not always, as this situation differs from one country to another). There are environmental pressures that may be faced, and the situation improves. Environment for a certain period, but it is due to its effectiveness from environmental stress again after the economy has gone through a later period of growth due to the inadequate response to dealing with it, as in the case of the water issue, due to the limited supply of the resource that is exposed to environmental pressure.

6. CONCLUSION

This study examined the impact of economic growth on the environmental pressure of Algeria's water consumption during the period 1980-2019. The self-regression model of distributed time gaps (ARDL) and the Granger causality were used to express the impact between the resulting variable, water consumed, reflecting water pollution and independent variables, GDP, reflecting economic growth, and the population of Algeria. The results of the long-term relationship between GDP and water consumption in Algeria have been achieved; there is a short-term one-way relationship between GDP and population and water consumption; The current ecoconnetse curve hypothesis in Algeria is incompatible, not in the short or long term; GDP is a significant cause of increasing water consumption and to a lesser extent population; excessive and increasing use of water intake, despite the limited resource; Water consumption for agriculture uses the enormous amount of water consumed in Algeria, followed by household use and industry; the environmental pressure model for water consumption in Algeria does not comply with the EKC-curve hypothesis.

This study also reached a set of proposals that would reduce the environmental pressure resulting from water consumption in Algeria and preserve this vital resource while keeping increased economic growth, for example, but not limited to: diversifying Algeria's GDP inputs to get out of the entire economy; Reducing the oil industries to limit petroleum pollution, which affects even groundwater; Using modern methods to reduce water waste during irrigation operations for agricultural purposes. The strict application of laws to preserve the environment, agricultural areas, as well as natural water reserves, which came in Law No. 03-10, related to the protection of the environment in the context of sustainable development dated February 17, 2003, to improve the business environment to reach sustainable growth and a clean environment that guarantees the future of future generations

As prospects for this study, it is proposed to expand the sample to include several Arab countries and compare those countries in the field of ways to combat environmental pressure resulting from water consumption. It is also proposed to conduct a study on the relationship between economic growth and water pollution in light of sustainable development dimensions (the economic, social, and environmental).

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8. Appendices

Appendice 1. ARDL test results

Dependent Variable : LWQ
Method : ARDL
Date : 02/01/21 Time : 03 :42
Sample (adjusted) : 1980 2019
Included observations : 39 after adjustments
Maximum dependent lags : 4 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (4 lags, automatic): LGDP LGDP2 LPOP
Fixed regressors : C
Number of models evalulated : 500
Selected Model : ARDL (3, 3, 3, 2)
Note: final equation sample is larger than selection sample

Variable	Coefficient	Std. Error	t-Statistic	Prob. *
LWQ (-1)	0.226453	0.199009	1.137904	0.2701
LWQ (-2)	-0.262434	0.224868	-1.167055	0.2584
LWQ (-3)	-0.420676	0.249861	-1.683641	0.1095
LGDP	6.396193	46.85786	0.136502	0.8929
LGDP (-1)	-9.250206	40.94647	-0.225910	0.8238
LGDP (-2)	-42.97829	42.44348	-1.012600	0.3247
LGDP (-3)	102.2655	31.95517	3.200280	0.0050
LGDP2	-0.480328	3.321343	-0.144619	0.8866
LGDP2 (-1)	0.967830	2.954190	0.327613	0.7470
LGDP2 (-2)	3.146884	3.029897	1.038611	0.3127
LGDP2 (-3)	-7.415537	2.314740	-3.203615	0.0049
LPOP	-500.4974	270.4440	-1.850651	0.0807
LPOP (-1)	1009.623	551.3324	1.831242	0.0837
LPOP (-2)	-509.7309	282.7141	-1.802991	0.0882
C	-197.3887	175.6998	-1.123443	0.2760

R-squared	0.967393	Mean dependent var	1.699893
Adjusted R-squared	0.942032	S.D. dependent var	0.306821
S.E. of regression	0.073872	Akaike info criterion	-2.070015
Sum squared resid	0.098227	Schwarz criterion	-1.389784
Log likelihood	49.15525	Hannan-Quinn criter.	-1.841138
F-statistic	38.14491	Durbin-Watson stat	2.311475
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent tests do not account for model selection.

Source: Eviews 11.

Appendice 2. ARDL test results

Estimation Command:
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ARDL LWQ LGDP LGDP2 LPOP @
Estimation Equation:

LWQ = C(1)*LWQ(-1) + C(2)*LWQ(-2) + C(3)*LWQ(-3) + C(4)*LGDP + C(5)*LGDP(-1) + C(6)*LGDP(-2) + C(7)*LGDP(-3) + C(8)*LGDP^2 + C(9)*LGDP2 (-1) + C(10)*LGDP 2 (-2) + C(11)*LGDP2 (-3) + C(12)*LPOP + C(13)*LPOP(-1) + C(14)*LPOP(-2) + C(15)
Substituted Coefficients:
LWQ = 0.226452644842*LWQ (-1) - 0.262433638601*LWQ (-2) - 0.42067635149*LWQ (-3) + 6.39619289757*LGDP - 9.25020560714*LGDP (-1) - 42.9782884386*LGDP (-2) + 102.26549369*LGDP (-3) - 0.480327911666*LGDP2 + 0.967829592928*LGDP2 (-1) + 3.14688449274*LGDP2 (-2) - 7.41553703023*LGDP2 (-3) - 500.497445282*LPOP + 1009.62310776*LPOP (-1) - 509.730865422*LPOP (-2) - 197.388687082
Cointegrating Equation:
D(LWQ) = -1.456657070805*(LWQ (-1) - (38.74157002*LGDP (-1) -2.59577235*LGDP2(-1) -0.41547379*LPOP (-1) - 135.50797497))

Source: Eviews 11.

Appendice 3. Johançon Cointegration Test

Date : 02/01/21 Time : 03 :53
Sample (adjusted) : 1980 2019
Included observations : 39 after adjustments
Trend assumption: No deterministic trend (restricted constant)
Series : LWQ LPOP LGDP2 LGDP
Lags interval (in first differences): 1 to 3

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob. **
None *	0.687794	99.36629	54.07904	0.0000
At most 1 *	0.632557	62.11537	35.19275	0.0000
At most 2 *	0.407977	30.07740	20.26184	0.0016
At most 3 *	0.340128	13.30270	9.164546	0.0078

Trace test indicates 4 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Source: Eviews 11.