Econometric study of the vulnerability of agricultural land in Algeria.

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Abstract:

The purpose of this study is to study the vulnerability of the area of agricultural land by ecological and economic factors. Temperature, precipitation, CO2 emissions and total population are the main variables in this study. The study is carried out in three parts, the first consists of presenting the method of estimating ordinary least squares (OLS), the second is based on the estimation of vector autoregressive models (VAR), and the third deals with the Granger causality test. Our empirical study shows that the total population and CO2 emissions are the main variables that significantly influence agricultural land.

Keywords: *Agricultural land, total population, ecological factors.*

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1. INTRODUCTION

Agricultural land is a determining variable in the availability of food production in quantity and quality. It is a strategic objective of the State to promote sustained local production and guarantee access for the entire population to daily food.

Land degradation results from a complex chain of causes making the clear distinction between direct and indirect drivers difficult. In the context of climate change, an additional complex aspect is brought by the reciprocal effects that both processes have on each other (i.e. climate change influencing land degradation and vice versa). (IPCC, 2019, p. 518)

Land in agricultural use (arable land and land under permanent crops) in the world as a whole has increased by only 155 million ha or 11% to about 1.5 billion ha between the early 1960s and the late 1990s. Nevertheless there were very significant changes in some regions. For example, the increase was over 50 percent in Latin America, which accounted for over one-third of the global increase. During the same period, the world population nearly doubled from 3.1 billion to over 5.9 billion. By implication, arable land per person declined by 40 percent, from 0.43 ha in 1961/63 to 0.26 ha in 1997/99. In parallel, there is growing preoccupation that agricultural land is being lost to non-agricultural uses. (FAO, 2003, p. 135)

In Algeria, agro-climatic models estimate that climate change will affect the area of agricultural land which causes the decline of the agricultural yield curve with a significant loss of biodiversity.

In 2018, the Algerian population numbered 42.4 million inhabitants, half of whom are under 25 years old, and the ONS extrapolations predict 51 million and more than 70 million inhabitants respectively in 2030 and horizon 2050. (O. Bessaoud, 2019, p. 10) Climate change and the growth of the total population are factors that threaten agricultural land in Algeria.

This study answers the following question:

What are the factors that influence the area of agricultural land in Algeria?

To answer this problem, a study is carried out in three parts, the first consists in presenting the estimation method of ordinary least squares (OLS), the second is based on the estimation of vector autoregressive models (VAR) and the third deals with the Granger causality test.

The methodology is the basis for the ratification of the research hypothesis:

Agricultural land is limited by population growth and climatic factors.

2. Agricultural land and climate change.

Climate change is a real threat to the area of agricultural land, which significantly influences global agricultural performance.

2.1. Agricultural land.

It is often said that the world faces the risk of land scarcity in the future. FAO research shows that this is not the case globally, although there are already severe shortages in some regions and regions, and this shortage is likely to worsen.

The clearing of new agricultural land will be less than in the past. During the period 1961-63 to 1997-99, the expansion of arable land in developing countries totaled 172 million ha, an increase of 25 percent. The growth required over the next 30 years will be only 120 million ha, or 13 percent. The task of bringing an additional 3.75 million ha per year into production may seem daunting, but this figure is lower than the annual rate of 4.8 million ha reached, in fact, during the period 1961-63 to 1997-99. (FAO, 2002, p. 40)

There is still potential untapped agricultural land. Currently, some 1.5 billion ha of land is used for arable and permanent crops, or about 11 percent of the earth's land area. (FAO, 2002, p. 40)

The reserve of available agricultural land is very uneven. Researchers fear the world is running out of arable land. Urbanization of agricultural land, soil degradation and other factors has exacerbated the trend of scarcity associated with population growth.

Much arable land is used for non-agricultural purposes. Calculating, about 40 hectares of land to house 1,000 people, hence population growth between 1995 and 2030, will devote more than 100 million hectares of land for infrastructure.

A more detailed estimate for the African continent reveals the heterogeneity of damage caused by climate change. The West Africa suffers the greatest losses amounting to between 36% and 44% of the losses for the entire continent. These damages represent losses between 42% and 60% of agricultural GDP in this region. The Sahara suffers the lowest absolute damages because agriculture in the Sahara has low value. However, the Sahara consistently loses the highest fraction of remaining agricultural value between 68% and 80%. (Mendelsohn, July 2000, p. 6)

Algeria’s status and the vastness of its territory constitute an important part of North Africa with approximately 238 million hectares of the total area. The landform to the north is often uneven, while the Sahara desert to the south occupies a large area. The main mountains are Tellien and the

Saharan Atlas and the mountains of the Sahara region. The distribution of the soil presents an area that reflects the distribution of the climate.

However, it is largely modified by the influence of bedrock, relief, water, vegetation, and biological and human factors. There are different types of floors:

• In a humid and semi-humid bioclimate, brown leached soil and brown limestone soil.

• In semi-arid and arid bioclimatics, humus-bearing soils such as chestnuts and browns generally accumulate a lot of calcium.

• Gray desert soil, primitive minerals due to erosion or erosion, and saline soil with arid and desert bioclimate.

In Algeria, agro-climatic models estimate that climate change will affect the water cycle leading to degradation of agricultural land, declining agricultural yield curve and loss of biodiversity.

Algeria, like all African countries, is facing the phenomenon of the loss of agricultural land through different economic policies. The latter are aimed at improving agricultural yields, in particular priority crops and land development. These policies have been implemented through various national plans such as the first quadrennial plan of 1970 - 1973, the National Agricultural Development Plan (PNDA) of 2001, the Five-Year Plan of 2010-2014 as well as the FELAHA Plan 2014-2020.

2.2. Climate change.

The expected effects of climate change for Africa confirm the perception that developing countries will see their agriculture significantly affected. In this region, already characterized by its low levels of quality of life and wealth, rudimentary agricultural practices would also be affected by climate change. For these nations, the impact of climate change would manifest itself more drastically compared to other countries. It should be noted that agricultural conditions in Africa are difficult, where actions are planned to improve the conditions of drinking water supply for human and agricultural consumption. However, the implementation of such programs is expensive and must provide for rigorous environmental management, therefore highly dependent on long-term funding and resources, generally unavailable in African regions.

Every region in Africa will experience some negative climate change impacts, but that some regions will be more vulnerable to warming than others. Northern and Southern Africa are expected to have losses from 0.4% to 1.3%. (Mendelsohn, July 2000, p. 5)

Recent climate changes in the Maghreb indicate that global warming is above the world average. Indeed, if the global temperature rise in the twentieth century is 0.74 ° C, the temperature rise in the Maghreb is between 1.5 and 2 ° C depending on the region, that's twice the average rise in global temperature. The World Meteorological Organization (WMO) declares that the decade 2000-2011 was the hottest in the history of the Maghreb and it was very affected by a variety of extreme weather and climatic phenomena (floods, droughts, hot and cold waves).

Analysis of climate change in Algeria shows that the impact of climate change is becoming more and more evident. Numerous studies have been carried out with the aim of showing the impact of climate change in Algeria (Belala and Hirche, 2013; Chabane, 2012; Dakiche, 2011; Djellouli, 2007; Nedjraoui et al., 2009; Nichane and Khelil, 2014 ; MATE, 2001; Tabet-Aoul, 2008) confirm that the country has undergone significant global warming with a significant drop in rainfall.

The rise in temperatures in the 20th century was between 1.5 ° C and 2 ° C in Algeria, more than double the global average rise or 0.74 ° C. (Tabet-Aoul, juin 2008, p. 6)

Climate change impact studies have shown that precipitation is decreasing; temperature tends to increase and that extreme events increase. By 2050, an increase in temperatures of 2 ° C to 3 ° C. and a drop in precipitation of 10 to 30%. (Chabane, 2012, p. 78)

In the Maghreb (North Africa), water availability is projected to decrease, particularly in the coastal areas. For 2050 under about 2°C warming globally, Milano et al 2013 project decreases in mean annual freshwater availability of greater than 50% in coastal catchment areas in Morocco and Algeria. Consistent with this is a decrease in river low flow by 2071-2100 of greater than 25% in coastal Morocco and Algeria projected by Van Vliet et al (2013) compared to 1971-2000. (PNUE, 2013, p. 10)

Therefore, studies have confirmed that drought in Algeria will be sharply intensified, making it more vulnerable to water stress and desertification.

Studies have been done on the region of western Algeria. They state that between 1926 and 2006, the temperature rises by more than 1.5 ° C and the average precipitation decreases by 10% to 20%.

The northwest and southwest regions of Algeria are the most affected by warming and reduced rainfall. Precipitation decreases and the interannual variability of precipitation increases, again approaching drought conditions.

The National Water Resources Administration (2009) conducted another study on the impact of climate change on water resources. The study was based on a series of rainfall data since 1900, the results showed that rainfall in the western part of the country decreased by 40%, the central regions by 30% and the eastern regions by 20%.

Algeria is increasingly faced with the resurgence of extreme weather accidents (storms, floods, heat waves), which increase its vulnerability.

In 2018, the National Climate Plan (PNC) carried out a risk and vulnerability analysis (ARV) for climate change. Water conservation, the fight against soil erosion and desertification, development of basins, diversification of activities, protection and expansion of forests, etc. were the main actions in the short and medium term, to face the impacts of climate change and in order to have a better use of agricultural land in the country.

3. Statistical analysis of the variables.

The variables analyzed in this section are climatic, agricultural and demographic variables. These variables are:

a) Total population;

b) Agricultural land;

c) CO2 emissions;

d) Temperature;

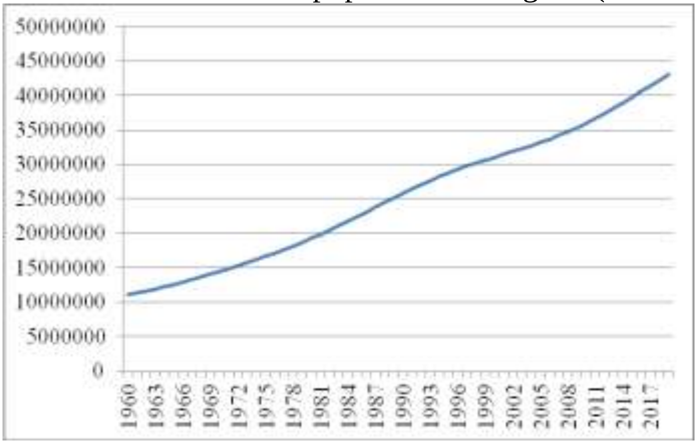
e) Precipitation.

The total population, temperatures, precipitation and CO_2 emissions are the main variables that directly influence the area of agricultural land. An evolutionary and historical analysis is carried out during the period 1960-2016 to observe the changes and trend that each of them.

3.1. The total population (million).

In the next decade (2020-2030), the active population (15-64 years) is expected to increase significantly, and currently represents two-thirds of the total population. As a result, the additional demand for jobs has become increasingly important, from 210,000 per year in the early 1990s to over 350,000 per year between 2020 and 2025, and will not decrease significantly until that the great generation retires. Age, around 2035-2040. This additional demand will naturally be added to the existing inventory of job seekers (1.2 million in 2008).

Fig N°(01): The evolution of the total population in Algeria (1960-2019).



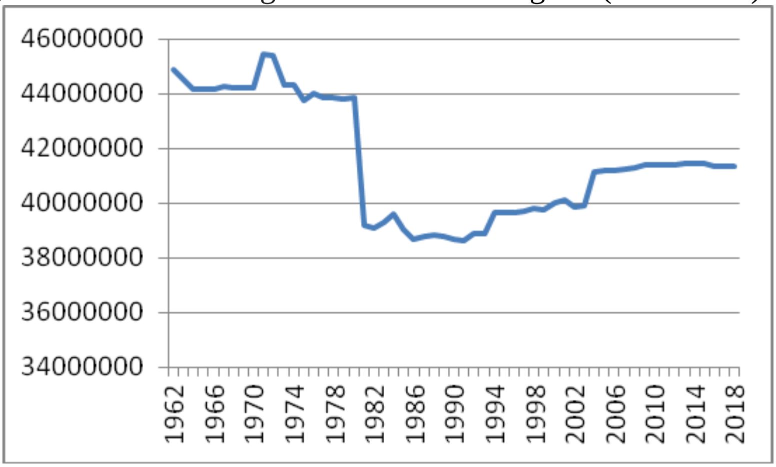
Source: ((Banque Mondiale, 2021)

Figure 1 shows the evolution of the total population over the period 1960-2019. The data show a clear increase in the Algerian population in absolute terms. In half a century, the Algerian population has multiplied by about four. During the period 1970-1980, the population growth rate exceeded 3% per year, and fell to 1.4% in the 1990s, which amounts to the increase in the rate of mortality and migratory factors in that time.

3.2. Agricultural land (hectares).

Agricultural lands includes: lands used for agricultural production, consisting of cropland, managed grassland and permanent crops including agro-forestry and bio-energy crops. (IPCC, 2007, p. 499)

Fig N°(02): The evolution of agricultural land in Algeria (1961-2018). (Hectares)



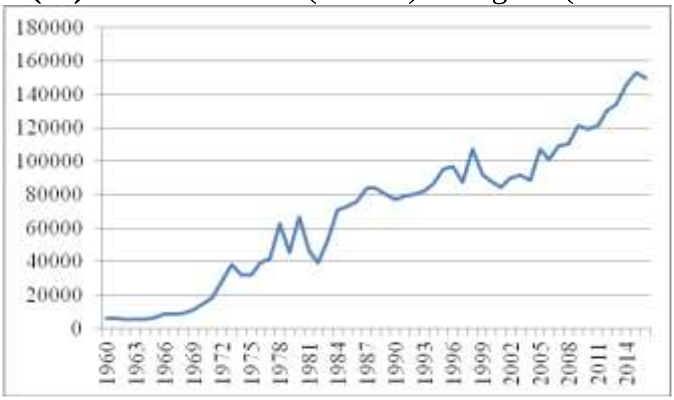
Source: (Banque Mondiale, 2021)

Figure 2 shows the evolution of hectares of agricultural land in Algeria during the period 1961-2016. The reduction in the number of land suitable for cultivation is significant, with a clear negative trend during the period analyzed. From 1980, with the boom in the oil sector and several demographic, economic and political changes, the area of agricultural land began to decline significantly. The population explosion significantly reduced the area of farmland by devoting it to construction.

3.3. CO2 emissions (kt).

The carbon dioxide (CO_2) emitted by the combustion of fossil fuels and biomass is used to produce energy, which greatly promotes the expansion of the greenhouse effect. It represents the main part that constitutes greenhouse gases. It is therefore a key issue in the fight against climate change.

Fig N°(03): CO2 emissions (kiloton) in Algeria (1960-2016).



Source: (Banque Mondiale, 2021)

Figure 3 shows the evolution in kiloton of CO_2 emissions during the period 1960-2016. A positive trend can be observed through the increase in CO_2 emissions during this period, with a steeper slope since the 2000s. Carbon dioxide is the main generator of pollution and climate change. Algeria has generated considerable amounts of CO_2 pollution, mainly due to its based economic model. The non-availability of technical and financial means to reduce these emissions has played a major role in the increase in the quantities emitted.

3.4. The mean annual temperature (C °).

The annual average temperatures are presented in degrees Celsius during the period 1960-2016.

Fig N°(04): The evolution of the annual average temperature (C °) in Algeria (1960-2016).

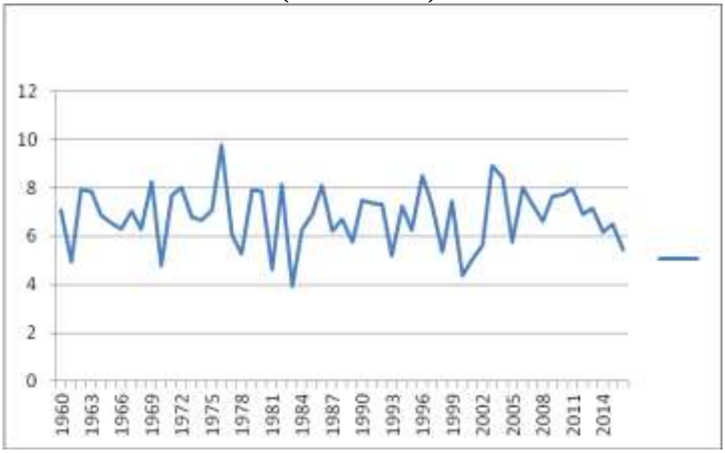
Source: (Banque Mondiale, 2021)

Figure 4 shows the change in the average annual temperature (C °) in Algeria between 1960 and 2016. The curve shows an increasing trend in average temperature during this period. Global warming caused by the emissions of various atmospheric pollutants, particularly CO_2, is the main cause of this rise in temperatures.

3.5. Average annual precipitation (mm).

Precipitation is the fall of liquid or solid particles of water. It is any type of water that falls on the surface of the earth. The different forms of precipitation include drizzle, rain, snow, hail, and snow.

Fig N°(05): The evolution of average annual precipitation (millimeters) in Algeria (1960-2016).



Source: (Banque Mondiale, 2021)

Figure 5 shows the evolution of the average annual precipitation measured in cubic millimeters during the period 1960 - 2016. The precipitation shows a cyclical trend, with either very high or very low peaks, the lowest peaks are observed in the years 1983 and 2000, while the highest peaks are observed in the years 1976 and 2003. From the data above, the presence of a decrease in rainfall cycles can be explained, since in 1960 the average rainfall exceeded 7 mm is a cumulative annual average of more than 84 mm and for 2016 the average rainfall is lower than this number approaching 5 mm, or about 65 mm as the cumulative annual averages.

The presence of climate change is one explanation for these phenomena, where there is an increase in temperature and a decrease in precipitation cycles (drizzle, rain, snow, hail, snow, water).

4. Econometric modeling and discussion of the results.

4.1. Variables and data used.

To determine the impact of demographic and climatological factors on agricultural land availability, the following variables are used: Agricultural land availability (AL) as endogenous variable and for exogenous variables: Population Total (Ptot), temperature (Temp), precipitation (Precip) and CO2 emissions (CO2). The data is taken from the latest World Bank database. The data cover a period from 1960-2016, or 56 observations. All data is annual.

The study is carried out in three parts, the first consists of presenting the method of estimation of ordinary least squares (OLS), the second is based on the estimation of vector autoregressive models (VAR) and the third deals with the Granger causality test. They are analyzes which allow to observe the existing relation between the dependent variables, independent, so that the correlation between the variables is demonstrated either positively or negatively.

In order to econometrically estimate a model, the first step is to study the stationarity of the time series using unit root test. The application of the ADF (Augmented Dickey Fuller) stationarity test shows that for a level of significance all the critical values predicted by the MacKinnon statistical tables, for the series used, are lower than the statistic (ADF). This means that the five series are non-stationary in level. Using the first difference (ADF) test to get the stationarity of all series.

After having stationary the series, we estimate the VAR (P) model containing the five previous variables with different P orders. We used the Akaike and Schwarz criteria to choose the optimal VAR order. According to our results, the delay number P that optimizes the VAR model is P = 1. So our optimal VAR is of order 1; [VAR (1)].

4.2. Estimation results.

Table 1 shows the results of the correlation between the study variables. A strong negative correlation is observed between the total population (Ptot) and the agricultural land variable (AL), it is close to 1 and equal to -0.88. The variables Precipitation (Precip), Temperature (Tem) and CO2 emissions are negatively correlated with (AL), the values correspond respectively to -0,19 -0,41 and -0,85.

Table N°(01): Correlation between the variables included in the econometric model.

	AL	Ptot	Tem	Precip	CO2
AL		1			
Ptot	-0,8762		1		
Tem	-0,4106	0,6751		1	
Precip	-0,1942	0,0522	0,1358		1
CO2	-0,8528	0,7821	0,4352	0,1603	1

Source: Personal production using Stata software.

4.2.1. Ordinary Least Squares.

Table 2 shows the method of estimating ordinary least squares, where the effects of total population (Ptot), temperature (temp) and precipitation (precip) and CO2 emissions (environmental pollution) on the availability of farmland are observed.

The results obtained are:

Table N°(02): Results of the ordinary least squares regression model.

AL	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
Ptot	-0,0743543	0,0115638	-6,43	0	-0,098124	-0,0505847
Tem	1951,571	568,2134	3,43	0,002	783,5921	3119,551
Precip	-1405,702	648,49	-2,17	0,04	-2738,692	-72,71148
CO2	-5,748695	1,935978	-2,97	0,006	-9,728155	-1,769235
_cons	1679278	256287,6	6,55	0	1152472	2206085
R-squared	0,8966					
Adj R-squared	0,8807					

Source: Personal production using Stata software.

From the table 02:

The t-value for all exogenous variables is less than 5%; this means that these variables are statistically significant.

The variable R^2 is equal to (0.88) which means that the dependent variable (Agricultural Land) is explained at 88% by the explanatory variables (Ptot,

Tem, Precip, CO2); the rest (12%) is explained by other variables. The variable R^2 is quite high, which suggests that the model is quite good.
The achievement has a 95% chance of occurring within this confidence interval, the distribution being normal and all the coefficients are within the confidence interval, which leads to a conclusion in favor of the stability of the parameters.
The results obtained show that the total population (Ptot) and agricultural land (AL) are negatively correlated; therefore, as the total population increases by one unit, the number of agricultural land decreases by about 0,07 hectares.
Temperature has a direct and positive relationship with agricultural land, if the temperature rises by about 1 ° C, agricultural land increases by 1951,57 hectares on average.
Precipitation and CO2 emissions indirectly and negatively influence the increase in agricultural land, from which it can be deduced that if rainfall increases by 1 mm and emissions by around 1 kiloton, agricultural land decreases on average of 1405, 70 and 5,75 hectares respectively.

4.2.2. VAR vector autoregressive model.

Table 3 reveals the results obtained in the VAR estimation. The first estimate corresponds to the first difference in agricultural land. As can be seen, the shifts in dal (first differences in agricultural land) are not transmitted over time, because their effect is not significant, since the variable z is greater than 5%. On the other hand, the shifts in the total population determine the number of agricultural land, these effects being statistically significant, and their inverse relationship; therefore, it can be deduced that when the total population of period t-1 increases by one unit compared to the previous period, the hectares of agricultural land decrease by 0,0088 hectares.
For the second estimate, the effects of the lags in the first differences in agricultural land and the lags in the total population for the total population variable are not significant, since the probabilities are greater than 5%, and logic proves it. The relationship between total population and agricultural land is inverse and / or negative, therefore, when one of them increases, the other decreases.

Table N°(03): Results of the regression model of the autoregressive vectors.

		Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
dal							
	dal L1.	0,063829	0,1991046	0,32	0,749	-0,3264088	0,4540667
	Ptot L1.	-0,008777	0,0043281	-2,03	0,043	-0,0172602	-0,0002943
	_cons	87529,75	52120,36	1,68	0,093	-14624,28	189683,8
R-sq 0.1495		chi2	5.0988		P>chi2		0.0781
Ptot							
	dal L1.	-0,033299	0,0177745	-1,87	0,061	-0,0681362	0,0015384
	Ptot L1.	1,002596	0,0003864	2594,9	0	1,001839	1,003354
	_cons	209396,1	4652,89	45	0	200276,6	218515,6
R-sq 1		chi2	7,00E+06		P>chi2		0

Source: Personal production using Stata software.

The five series used (AL, Ptot, Temp, Precip, CO2) are all integrated of order (I), so there may be a possible cointegration relationship between them. The next step is therefore to study cointegration using the Johansen Trace test.

4.2.3. Johansen's Trace test.

Table 4, the cointegration test is used to observe whether the variables are related in the long run. The results obtained by the test show that there is a cointegration (long-term relationship) between the variables (dal) and Ptot. This is seen by virtue of the statistical trace values. When these values exceed their critical values (5% critical value), it is assumed that there is a long-term relationship between the variables studied.

Table N°(04): Cointegration test.

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	6	-576,03123	-	16,4975	15,41
1	9	-567,80769	0,44423	0,0504*	3,76
2	10	-567,78247	0,0018		

Source: Personal production using Stata software.

4.2.4. Granger causality test.

Granger's method checked whether there is unidirectional or bidirectional behavior. When the probability is less than 5%, it is assumed that there is causality; therefore, Ho is accepted (null hypothesis), in the opposite case where the probability is greater than 5%, H1 is accepted (alternative hypothesis), which supposes the non-existence of causality between the variables.

Table N°(05): Wiener-Granger causality

Equation	Excluded	chi2	df	Prob>chi2
dal	Ptot	4,1127	1	0,043
dal	All	4,1127	1	0,043
Ptot	dal	3,5097	1	0,061
Ptot	All	3,5097	1	0,061

Source: Personal production using Stata software.

Table 5 shows the existence of causality between the variables: Agricultural lands and Total population. The results obtained show that there is no bidirectional causal behavior between the variables. The behavior is unidirectional, i.e. the result of the total population (Ptot) causes in Granger's sense the result of the first differences in agricultural land (dal), but the result of dta does not predict the result of Ptot.

In this case, Ho is accepted for the farmland equation (dal), because the probability is equal to 0,043 or 4,3%, result less than 5%; this means that the results of the total population cause the results of agricultural land. However, the result is the reverse for the total population equation, since the probability is greater than 5% and equal to 6,1%, it means that the farmland result does not cause the total population result.

4.3. Discussions of results.

The main research results reflect population growth in the face of decreasing agricultural land area. At the time to also reveal that climate change and environmental pollution are variables that greatly influence the availability of land used for agriculture.

The total population of period t-1 significantly influences the model, which leads to the conclusion that population shifts have negative effects on the area of hectares of agricultural land. Likewise, the existence of a long-term relationship between these variables was verified.

Other results obtained revealed the existence of a one-way causal relationship between the total population and agricultural land, that is, the total population causes the results of agricultural land, while agricultural land does not cause the results of the people.

The main result is that the total population has a negative influence on the area of agricultural land. Therefore, if the population increases by one unit, approximately 0,07 hectares of agricultural land decreases, this relationship being statistically significant.

The negative and indirect relationship between the variable total population and agricultural land is consistent with empirical evidence, which indicates that population increase reduces the land that was once used for agriculture, becoming construction areas and urbanized areas. . On the other hand, an increase in the pressure on existing cultivated land, in order to make them more productive, but with an unfavorable effect on over-exploitation, generating a gradual reduction in their quality.
The increase in the total population directly and negatively influences the area of agricultural land, leading to a decrease in production (in quantity and quality) which reinforces the country's food insecurity.
On the other hand, climate change also affects the area of agricultural land, with a direct effect in the case of average annual temperature and an inverse effect in the case of average precipitation. When the average temperature increases by 1 ° C, the hectares of agricultural land increase around 1951,57. If rainfall increases by 1 mm, hectares of agricultural land decrease by an average of 1405,70.
The evidence produced by the results clearly shows the negative effect of rainfall variability on agricultural land. Extreme weather events cause soil erosion and, consequently, reduction of agricultural land as well as reduction of agricultural production.
Environmental pollution is a very determining factor of agricultural land; an inverse relationship is shown in this study, if one kiloton of CO_2 emissions is increased, hectares of agricultural land decrease by 5,75. It is identified as one of the causes of soil degradation, leading them to be less and less productive.

5. Conclusion

From the results reveled in this research, it is concluded:
a) The study notes that the increase in population is reducing land formerly used for agriculture to areas used for construction and other uses. As farmland shrinks, the amount of food needed to satisfy the population will decrease.
b) The results obtained by the ordinary least squares estimates reveal the decrease in agricultural land in the face of a continuous increase in the total population, which has consequences for the national capacity required to meet domestic demand, jeopardizing the food security of Algerians.
c) Climate change also affects hectares of agricultural land. The evidence shows the negative consequences. The results show that temperature and

precipitation greatly influence the amount and availability of agricultural land.

d) Environmental pollution (CO2 emissions) is a determining factor of agricultural land and is the cause of soil degradation, which makes it less and less productive.

Finally, it is conclude that the area of agricultural land is limited by population growth and climatic factors, which confirms the hypothesis of this study.

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