The joint effect of financial development and human capital on the ecological footprint: The Algerian case

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Abstract

This study aims to figure out what factors influence environmental degradation as measured by the ecological footprint in Algeria. It examines the impact of financial development (access to credit), human capital (education), and economic growth on Algeria's environmental degradation in the short and long term. For this purpose, the current study examines short- and long-term consequences using a 37 years time series of secondary data and applies the "autoregressive distributed lag" time-series model. Our findings show that economic growth has a considerable positive impact on the ecological footprint in both the long and short term. Both access to credit and education have a negative effect on environmental degradation. This suggests that access to credit and education are both negative short- and long-term derivatives of the ecological footprint in Algeria, whereas economic growth is a positive short- and long-term indicator. Furthermore, bidirectional causality is discovered between access to credit and ecological footprint, while the granger causality method discloses unidirectional causality from economic growth to the ecological footprint. Education also Granger-causes ecological footprint without any feedback. The current research has significant consequences since it will assist Algerian policymakers in controlling environmental deterioration through improved regulations. The findings inspire Algerian authorities to encourage the human resource to adopt green development through proper education programmes. Additionally, investors should be encouraged to finance environmentally friendly, sustainable projects. Furthermore, in Algeria, the government should reduce pollution from production by implementing green technologies. And participate in an international development track that is focused on long-term sustainability.

Keywords: financial development, human capital, ecological footprint, economic growth, Algeria.

JEL classification: G2, J24, Q01, F43

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1. Introduction

Sustainable development has become a priority and a primary goal for every country worldwide, considering that it is a comprehensive concept based on three fundamental pillars: social, economic, and environmental. However, embodying and achieving this goal and these dimensions is not accessible due to an apparent contradiction. Environmental degradation has become an obstacle to economic and social development goals, as a result of the rapid depreciation of natural resources in the production processes, of the increasing emissions of greenhouse gases in the use of fossil energy, which created challenges for the international community, and for its dangerous effects on human health and environmental conditions (Ulucak et al., 2019).

The most of studies that analyzed the link between economic growth and the environmental quality indicate that energy consumption increases with the rise in income in emerging markets and developing countries, while energy consumption decreases in developed countries with increasing income beyond a threshold level point, a pattern which is called the environmental Kuznetz curve (Chang, 2015). Fewer studies consider the role of financial development in influencing environmental quality. In this regard, they indicate that the higher the financial development (such as the size of the bankig sector or of credit in a country economy), the higher the efficiency of the use of natural resources, while in the backward regions, the use efficiency of natural resources is low, which means that economic development depends on an excessive exploitation of natural resources (Zameer et al., 2020). This means that the development of the financial sector leads to a resource efficient economic growth. Countries with a robust financial industry are more likely to develop clean environmental markets than countries with weak financial markets. A stable financial system helps to improving the environment by encouraging investments in environmentally friendly technologies (Nasreen et al., 2017).

The mutual influence between the pillars of the sustainability of modern development does not stop between the economic and environmental dimensions but extends to the social one. With the exponential growth of the population, a country economy must satisfy more and more social desires and needs, leading to an increased pressure on earth's natural resources, wildlife and marine life and ecosystems.. Yet, we can take the necessary measures to stop this deterioration by directing attention to the environment we live in through education and human awareness (Aye & Edoja, 2017).

In other words, the social dimension of sustainable development is based on human capital, which confirms the importance of investigating the links between economic growth, financial development, and human capital and the extent to which they are related to the environment.

As a field for our applied study, we chose Algeria as a model because it has more than 238 million hectares, and it is the largest Arab country in area. Forests accounted for 2.3 million hectares of this area, agricultural land is 8.4 million hectares, and pasture land is 33 million hectares. Even if Algeria is rich in energy and mineral resources, available land for agriculture and water resources are relatively scarce. Algeria has also experienced a population increase, with an estimated population of 45 million in 2021. The average per capita ecological footprint (the impact of human activities measured in terms of the area of biologically productive land and water required to produce the goods consumed and to assimilate the wastes generated including carbon dioxide emissions SOURCE) in Algeria is 1.9 hectares (GFN, 2020); even if this is less than the worldwide average ecological footprint per capita, it exceeds the global bio-capacity rate available per capita (Sakmar et al., 2011). Experts expect a significant increase in the rate of the ecological footprint in Algeria in the coming years. Under the influence of key driving forces, including the continuous increase in the population, the limited availability of productive lands, and the social lifestyle dependent on waste, Algeria should find a new path to economic development by using its natural resources in a more efficient and sustainable way.

The Algerian government announced the outlines of the economic and social recovery plan (July 13, 2020) to sustain the national economy after the repercussions of the collapse of oil prices and the economic stagnation caused by the Covid-19 pandemic. The plan is designedto achieve a growth rate of 6.5% of GDP annually outside hydrocarbons during the period between 2020 and 2030. The Algerian government's vision includes increasing the volume of investment in renewable energies and enhancing the efficiency of energy consumption.

The relationship between economic growth, financial development and human capital, on one side, and environmental degradation on the other side, is significant for a developing country like Algeria, which aspires to reach an economy less dependent on fossil energy according to the 2013 Plan "Vision 2030" (Government of Algeria, 2020). Attention to environmental aspects is a source of concern for the government, in the context of transforming its economy from a traditional rentier economy to a modern industrial economy by 2030.

Algeria was chosen as a case study due to its economic complexity as it depends on revenues from natural resources, particularly oil resources. It is one of the rich oil economies, and the study of environmental quality is of great importance for an oil country like Algeria. Following Nathaniel's (2012) arguments, financial resources have been highlighted as one of the powerful forces driving economic growth. On the other hand, as an oil nation, Algeria is under the intensity of the environmental challenges generated by the oil and gas industry. The chronology of financial and human resource development in Algeria is an emerging priority that leads to developing the country's social and economic systems. Algeria witnessed a political and social crisis that began in the nineties, damaging much of its country performance indexes and total equilibrium.

Nevertheless, access to substantial financial resources during periods of high oil prices (for example in 2001) allowed to finance a subsidized program of interventions and laws promoting education, science research and economic development (Chaib & Siham, 2014).

In this paper we apply econometric methods to research the factors that could contribute to economic growth without necessarily impairing environmental quality, and we believe that human capital (education) and financial development (the role of credit and banking in a country economy) are among the key factors that can contribute to a green growth. Therefore, the study aims to investigate the effect of economic growth, human capital and financial development on the ecological footprint in Algeria.

More precisely the purpose of this study is to investigate the combined effects of economic growth, credit size and education on an oil-producing country's ecological footprint by using an econometric method called AutoRegressive Distributed Lag (ARDL). This paper analyzes the environmental impacts related to a country economy by using a comprehensive indicator, the ecological footprint, rather than the more diffused but limited indicator, carbon dioxide emissions, to better reflect environmental degradation in Algeria. To the best of our knowledge, it is the only study that addresses the joint effects of economic growth, financial development and human capital on ecological footprint in Algeria.

The paper is divided into four sections: after the introduction, section 2 shows the literature review; section 3 presents the research methodology (econometric model, robustness tests, results from discussion and findings). Finally, in section 4, the conclusion and policy recommendations.

2. Literature review

Improving the financial services in an economy (ease of access to credit, low costs) can contribute to sustainable development objectives (SDGs) and improve human well being.

Emphasize the link between financial development (FD) and ecological footprint (EFP) can be found in various research. Godil et al. (2020) demonstrate that tourism, globalization, and financial development are positively and significantly linked to EFP in Turkey. The study suggests that a rise in these factors will increase Turkey's EFP. Various scholars In Pakistan have observed an asymmetric correlation between credit size and the environment (Majeed et al., 2020). However, some results in Nigeria (Omoke, Nwani et al., 2020) demonstrate that the positive shock to FD (increase in FD) has a significant impact on decreasing the ecological footprint (i.e., enhancing environmental sustainability). In contrast, the negative shock to FD (decrease in FD) increases impact on ecological footprint (i.e., degradation of ecological sustainability.

As for the research that encompassed numerous countries, we discovered a study (Sharma et al., 2021) that covered eight developing nations of South and Southeast Asia**.** It found that per capita income, energy solutions, growth, and FD have boosted the EFP in the long term. A research covering 58 countries (Ehigiamusoe et al., 2019) reveals that the financial system structure is vital to safeguard environmental quality. More precisely, FD promotes environmental quality. From another global sample of 100 countries, empirical data verified the direct positive impact of FD on ecological degradation (Bui, 2020). The development of the financial system also raises energy consumption, leading to additional harmful emissions.

Coming to literature on the link between environmental quality (EQ) and human capital (HC), it can be said that HC is connected to EQ in different ways based on the variables that explain both concepts. A research encompassing G7 countries (Ahmed et al., 2020) reveals that urbanization enhances the EFP, whereas human capita development (education) diminishes it. Moreover, a study of Ahmad et al. (2021) on 17 emerging countries has proven that increasing HC and institutional quality can reduce environmental degradation in the short and long term. In the same sense, excellent institutionalization and political governance help improve FD and lower carbon emissions, and here we are talking about the case of Saudi Arabia (Omri et al., 2021). In a similar study the case of Nigeria was analyzed (Yinusa et al., 2020); the results revealed a long-term relationship between institutional quality, FD, and inclusive growth.

One of the most widely used and popular hypotheses to explain the causes of environmental degradation is the Environmental Kuznets Curve Hypothesis (EKC). It was proposed by Grossman and Krueger (1991, who reviewed the original study by Kuznets (1955). According to the EKC hypothesis, there is a negative relationship between environmental quality and low per capita GDP in the early stage of development, but later a positive relationship appears between environmental quality and high per capita GDP.

Besides the EKC hypothesis, researchers typically test the pollution haven hypothesis (PHH) that links environmental degradation with foreign direct investment. This hypothesis argues that all companies seek to avoid the cost of strict environmental regulations and high energy prices by choosing countries where environmental standards are laxer. Often when industrialized countries seek to establish factories abroad, they look for the cheapest option in terms of resources and labor. This hypothesis assumes that weak environmental regulations will attract multinational corporations in terms of shifting their highly polluting industries to developing economies because they have less stringent environmental policies (Mert & Bölük 2016; Sarkodie & Strezov, 2019).

A group of studies is focused on the link between income and environmental degradation, often motivated by the Kuznet's finding of an inverted U-shaped relationship between per capita GDP and environmental deterioration. In the Uruguay case, Ergun et al. (2020) discovered that environmental degradation is positively correlated with long-term per capita energy usage, while its relationship with FD is negative. According to them, the EKC hypothesis has been proven in Uruguay. As for Turkey, Bulut (2021) suggests that the EKC is dominant, whereas the pollution haven hypothesis (PHH) is not dominant in Turkey. The results of the study also reveal that EFP (narrow meaning) is negatively correlated with renewable energy use, whereas industrialization does not affect EFP.

Results from Nigeria (Omoke, Opuala-Charles et al., 2020) show that FD has significant effects on CO_2 emissions: an increase in a bank credit to the private sector decreases CO_2 emissions in the long-run. For Tunisia, Ghazouani (2021) reveals that EG (Economic Growth) and crude oil prices positively affect the co_2 emission, while the negative component of FDI validates the PHH hypothesis. A study on the United Arab Emirates case found that the relationship between FD and CO_2 emissions was U-shaped and inverted N-shaped. (Shahbaz et al., 2020). While from Lebanon, Taher (2020) indicate that FD and growth has a significant and positive impact on CO_2.

In MENA countries, Nathaniel (2020) suggests that FD, growth, and urbanization increase ecological damage. The data also demonstrate that renewable energy does not contribute to environmental quality, whereas usage of non-renewable energy significantly causes environmental degradation. In the 15 highest CO_2 per capita emitting countries, FD and renewable energy help reducing environmental degradation. FD, renewable, and non-renewable energy boost growth (Usman et al., 2021). And so on, In OBORI[1] (One Belt and One Road Initiative) countries, Lu (2021) finds that increasing FD and globalization reduce energy use. The FD (domestic credit as % of GDP) contributes to sustainable ecpnomic growth. Overall, for the GCC (Gulf Cooperation Council) countries, Yang et al (2021) found that globalization, FD, and energy usage contribute to a considerable degradation in the quality of the environment.

In a study that covered OECD countries (Destek & Sinha, 2020), the average group data reveal that the theory of the inverted U-shaped EKC does not apply. Furthermore, this study highlights that an increased use of renewable energy decreases the EFP while increased consumption of non-renewable energy increases environmental degradation. Even though Destek & Sinha (2020) discovered that the increase in energy use and globalization enhance the EFP in GCC countries, they deny the existence of the EKChypothesis.

Coming to the rare studies on the Algerian case, a recent one (Touitou & Langarita, 2021) reaches interesting results: the overall findings of the ARDL regression on the 1973-2016 time series seem to confirm the EKC's hypothesis in the long run (the turning point of the ED curve is reached for a very high GDP per capita value) for a for. The study indicates the presence of a longstanding positive relationship between CO_2 emissions and real GDP (algeria will continue to increase emissions) and show that the direction of this relationship moves from economic growth to CO_2 emissions as per Granger causality tests. In another study related to Algeria, Bensafta (2021) shows a low rate of energy efficiency in Algeria, confirming the substantial argument of energy waste and non-rational use (Bensafta, 2021).

By using an ARDL (autoregressive distributed lag) with a breakpoint technique, Amri (2017) illustrates the positive impact of non-renewable energy on CO_2 emissions consumption. Conversely, it demonstrates a small effect of renewable energy use on environmental quality improvement. Further, the same study accepts the EKC hypothesis. However, the most considerable gross domestic product value in the logarithm level of that data is less to the projected turning point. Bouznit & Pablo-Romero (2016) showed that EKC is validated in the period 1970-2010. However, the stopping criterion is met for a very high GDP per capita value. This study suggests that economic growth in Algeria would continue to raise emissions. Results also reveal how increased energy use and electricity usage increase CO_2 emissions.

3. Methodology and data

To investigate the relationship between ecological footprint (EFP), GDP per capita (GDP), credit size (FD), and education (HC) in ALGERIA, we employ an autoregressive distributed lag (ARDL) model in the 1980-2017 timeframe. Before explaining the method, an explanation of the variables we have chosen for the specification of the model is needed (see also table 1 for an overview of the indicators and related sources).

[1] The Belt and Road Initiative is an initiative strategy adopted by the Chinese government to invest in nearly 70 countries and international organizations.

Table 1 – Variable definition and source of the data

Concept	Acronym	Indicator and unit of measure	Source
Ecological footprint	EFP	Ecological footprint per person (Global hectares)	GFN (2020)
Economic growth	EG	GDP per capita (Constant 2010 US dollars/Algerian population in the related year)	WDI (2020)
Human capital	HC	Index based on years of schooling and returns to education	Penn World Table version 10.0 (2021)
Financial development	FD	Domestic credit to firms (private sector only) (% of GDP)	WDI (2020)

Many studies have focused on carbon dioxide emissions as a measure of environmental degradation, which is an important aspect of the environment. But it is not a comprehensive measure, in our opinion. This study analyzes the environmental quality in Algeria through a more comprehensive measurement, which is the ecological footprint Using the ecological footprint as a proxy of environmental degradation allows environmental degradation to be represented in a more comprehensive scale. Instead of focusing on air pollution only, the ecological footprint adds soil and water pollution as well. This reflects a better illustration of the role of human resources in the environment. The Ecological Footprint calculates how much biologically productive area is required to produce the resources required by the human population and to absorb waste and humanity's carbon dioxide emissions. The ecological footprint takes into account the use of resources such as built-up land, grazing land, forest products, agricultural land, hunting grounds, forest products, and carbon emissions as well (Pata et al., 2021; Udemba, 2020). Ecological footprint is measured in global hectares per person: since trade is global, an individual or country's Footprint includes the consumption of land or sea area from all over the world. Country level footprint data are provided by the Global Footprint Network database (GFN, 2020).

The ecological footprint is used as an indicator of environmental quality for two reasons. First, the ecological footprint comprises different types of biological land use: fishing grounds, grassland, pastureland, cropland…etc. Second, the Ecological Footprint is a comprehensive and widely accepted proxy of environmental quality, and it is easy to use for comparison between countries (Ahmed, Asghar et al., 2020; S. P. Nathaniel, 2021a, 2021b). With an emphasis on environmental degradation in Algeria, we chose ecological footprint as a better proxy for the environment (Yang et al., 2021). The choice of EFP is also based on the fact that this indicator includes the biologically productive area required to absorb humanity's carbon dioxide emissions; so it takes into account the CO_2 emissions related to the extraction and use of natural resources such as oil and gas.

The study's control variable includes economic growth, which is measured by gross domestic product per capita (constant 2010 US$).

Human Capital needed to improve environmental performance has been studied, either directly or indirectly by considering the role of advanced education and of spillover effects such as technology and knowledge transfer. The Human capital

(HC) index is based on schooling and returns to education and is is retrieved from Penn World Table version 10.0 (PWT 10,2021)[2].

As to Financial development, it is proxied by "Domestic credits to the private sector" (percent of GDP) ,taken from the World Development Indicator WDI (WDI, 2020).

4. Model implementation and discussion of results

Coming to the econometric analysis, the procedure adopted the following steps: We firstly used descriptive statistics and correlation matrix to find out the nature of the variables in terms of their mean and standard deviation and the extent to which they are related to each other (4.1). We then used unit root tests to check for the order of integration of the data series before moving on to econometric analysis (4.2). Third, we used the bound test to examine if the variables had any long-term associations (4.3). In order to empirically analyse the long-run relationships among our variables, we apply the Bound test cointegration. The bounds test is based on the F-statistic which its asymptotic distribution is non-standard under the hypothesis of no cointegration. (4.4). If the ARDL bounds test found the variables to be co-integrated, then the long-run parameters (4.5) and short-run coefficients (4.6) along with the ECM term are calculated. Then, we conducted a Granger causality test to evaluate the causality relationship between our variables (4.7). Finally, for a robustness check, we used many diagnostic tests (4.8 and Annex 1).

We model the sensitivity of the ecological footprint to the economic growth, human capital, and financial development in Algeria during the period from 1980 to 2017 with the following equation, that represents the general form of Algeria's ecological footprint function:

$$EFP = f(GDP, FD, HC) \quad (1)$$

Where the ecological footprint (EFP) is the dependent variable, while education (HC), economic growth (GDP), and credit size (FD) are the explanatory variables. The logarithmic function gives better results than the linear function in terms of stability of variance and interpretation of the estimated results through elasticities (Usman et al., 2021). In addition, it helps to eliminate heteroscedasticity, control for outliers, and reduce "noise" in the Model (Okoro et al., 2021). Thus, the empirical equation In (Eq.(1)) can be re-written as follows:

$$lnEFP_t = \alpha + \beta_1 lnGDP_t + \beta_2 lnFD_t + \beta_3 lnHC_t + \varepsilon_t \quad (2)$$

[2] The average number of completed years of education of a population, is a widely used measure of a country's stock of human capital. The index is calculated based on the average years of schooling from Barro and Lee (BL, 2013) and an assumed rate of return to education, based on Mincer equation estimates around the world (Psacharopoulos, 1994). Average years of schooling: average number of completed years of education of a country's population aged 25 years and older, excluding years spent repeating individual grades.

Ln EFP, lnGDP, lnFD, and lnHC are the natural logarithms of ecological footprint, gross domestic product, credit size, and human capital index.

Where α is the constant term and $EFP_t$is an ecological footprint that measures humans' pressure on the planet (expressed in global hectares – gha). HC_t is the human development index and it is based on years of schooling and returns to education. FDt is financial development proxied by real domestic credit to the private sector percentage of GDP, and GDPt is real GDP per capita used as a proxy of economic growth. ε_i is the error term assumed to be normally distributed with constant variance and zero mean. We suppose that a rise in economic growth will increase the ecological footprint and $\beta_1 > 0$. $\beta_2 < 0$ an increase in financial development is linked with low environmental degradation. $\beta_3 < 0$, a good human development index will improve the environment.

Equation (2) measures the effects of independent variables on the ecological footprint. Thus, we applied the distributed autoregressive Model (ARDL) presented by Pesaran et al. Equation (1) is transformed based on the unconstrained error correction model (UECM) as follows:

$$\Delta lnEFP_t = \alpha + \beta_1 lnEFP_{t-1} + \beta_2 lnGDP_{t-1} + \beta_3 lnFD_{t-1} + \beta_4 lnHC_{t-1} + \sum_{i=1}^{a} \theta_1 \Delta lnEFP_{t-i} + \sum_{i=1}^{b} \theta_2 \Delta lnGDP_{t-i} + \sum_{i=1}^{c} \theta_3 \Delta lnFD_{t-i} + \sum_{i=1}^{d} \theta_4 \Delta lnHC_{t-i} + \varepsilon_t (3)$$

Where Δ indicates the first difference. EFP, GDP, FD, and HC are ecological footprint, gross domestic product, financial development, and human capital. α is the constant, t is time, ε is an error term. Furthermore, a, b, c, and d indicate the optimal lags are selected based on Akaike information criterion (AIC) and SC, and θ_1,θ_2,θ_3,$\theta_4$are short-run coefficients and β_1,β_2,β_3,β_4 are long-term coefficients. In the ARDL model, the long-term nexus among the series is tested by:

$$H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$$
$$H_1: \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq 0$$

According to (Pesaran et al., 2001b), the acceptance or rejection of the null hypothesis depends on the results of the Fisher test. A long-run relationship exists if the value of the Fisher statistic is greater than the value of the upper bound. But if the value of the Fischer statistic is less than the lower bounds value, there is no long-term relationship. As for the case of indecisiveness, the F statistic value appears between the upper and lower limits.

However, since Pesaran et al. (2001b) computed critical values for high sample sizes (500-1000), these strong values cannot be applied for small sample sizes (Narayan & Smyth, 2005). As a result, Narayan (2005) came up with new critical values for small sample numbers (30-80). We looked at these numbers to see whether there was a long-term connection between the series.

Pesaran et al. (2001) proposed the ARDL model. It has some advantages, unlike other co-integration approaches. The ARDL co-integration technique can be used with the lag length for dependent and independent variables, while other co-integration forms require similar lag lengths (Engle & Granger, 1987; Johansen & Juselius, 1990). The ARDL co-integration model can be used if the variables are stationary at level or the first difference, or a combination of both. Moreover, it is preferable to use the ARDL model if the sample size is relatively small (Khan et al., 2019). If there is a long-term nexus, a short-term relationship can be tested as follows:

$$\Delta lnEFP_t = \delta + \sum_{i=0}^{k} \varphi_1 \Delta lnEFP_{t-i} + \sum_{i=0}^{l} \varphi_2 \Delta lnGDP_{t-i} + \sum_{i=0}^{m} \varphi_3 \Delta lnFD_{t-i} + \sum_{i=0}^{n} \varphi_4 \Delta lnHC_{t-i} + \gamma ECT_{t-i} + \varepsilon_t \quad (4)$$

where ε_t Is the error term, γ is the ECM coefficient, shows the speed of adjustment to long-run equilibrium. The estimated Error Correction Model (ECM) captures the rate at which environmental deterioration adapts from short-run to long-run equilibrium levels.

4.1. Descriptive statistics and correlation matrix

The descriptive data are at the top of (Table 2), and our variables analyzed for association analysis are listed below. Ecological footprint, credit size, and education negatively correlate, whereas gross domestic product positively correlates with our dependent variable.

Studies indicate that testing the correlation between the study variables will enable us to know the extent of the high correlation between the independent variables, making the estimates contradict the economic theory resulting from multicollinearity between the independent variables (Agung, 2009). However, the multicollinearity relationship between the variables only occurs when the correlation value is more than 0.95% (Iyoha, 2004). Based on the result (Table 2), all correlation coefficients are less than 0.90%, which indicates no tendency for collinearity among the explanatory variables.

Table 2 – Descriptive statistics

	EFP	**EG (GDP per capita)**	**FD (Credit Size)**	**HC (education)**
unit of measurement	gha per person	(Constant 2010 US$)	(% of GDP)	Index
Mean	1.7024	3436.197	27.3363	1.7740
Median	1.5103	3325.154	14.5997	1.8322
Max	2.5164	4224.035	69.2841	2.3027
Min	1.2189	2783.153	3.9046	1.2524
Std.Dev	0.3889	442.21	24.1579	0.3104
Skewness	0.8151	0.3431	0.7724	0.1415
Kurtosis	2.2172	1.8026	1.8655	1.8159
Observation	38	38	38	38
EFP	1			
EG (GDP p.c.)	0.90	1		
FD (credit size)	-0.032	0.185	1	
HC (education)	-0.306	-0.415	0.1	1

Table 2 presents the summary statistics. The mean ecological footprint is 1.7024 gha per person with a standard deviation of 0.38 gha per person. Mean GDP per capita for the same period is 3436.19 USD with a standard deviation of 442.21 USD, while domestic credit to the private sector has a mean of 27.33 % of GDP with a standard deviation of 24.15% of GDP. The mean human capital index is 1.77, with a standard deviation of 0.31.

4.2. Unit root tests

The objective of the econometric analysis is to obtain unbiased estimation results in order to better define the relationship between the study variables. Through the unit root tests, the order of integration is determined. It is known that most economic variables are non-stationary, and in order to avoid spurious estimation results, we resort to the unit root test. In this study we use the PP and ADF tests.

Examining the properties of the variables is the first step in ARDL model estimation. The study employed Dickey & Fuller (1979) and Phillips & Perron (1988) unit root tests to determine stationarity and the same outcome. Because both the ADF (Augmented Dickey Fuller) and PP (Phillips Perron) tests reveal that the variables are stationary at the first difference, as shown in Table 3.

The results of the unit root test are reported in Table 3. The unit root test results revealed that all of our variables, have unit roots, indicating that they were not stationary at the level but the level first difference. Therefore, we justified applying the ARDL model in the analysis because we have a mixture of integration I(0) and I(1) (Pesaran et al., 1996, 2001a).

Table 3 – Unit root tests

	ADF test statistic			PP test statistic		
	I(0)	I(1)	Decision	I(0)	I(1)	Decision
EFP	-0.488	-7.695***	I(1)	-0.488	-7.737***	I(1)
FD (Credit size)	-1.313	-4.915***	I(1)	-1.494	-4.965***	I(1)
HC (education)	-2.416	-7.532***	I(1)	-2.627*	-7.532***	I(1)
EG (GDP per capita)	-1.01	-3.233**	I(1)	-0.245	-3.296**	I(1)

Note: * indicates significance at p-value<0.05, ** indicates significance at p-value<0.01, ***indicates significance at p-value<0.001

Table 3 presents the unit root tests, Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP). The ADF test and PP test findings show that each selected variable accepts the null hypothesis at a level that validates the presence of the unit root in all of the variables. Thus, each variable became stationary after the first difference, like an ecological footprint, financial development, human capital, and GDP. Both tests produce trustworthy findings and reveal the ARDL model’s direction.

The null hypothesis is rejected since EFP, FD, HC, and GDP demonstrate stationarity at the first difference, as shown in the table. This shows that these series are

I(1). As a result, the stationarity of the variables has been established, and the ARDL modelling requirement of the series is I(0) or I(1) has been met.

4.3. Optimal Lag length

The "Aikeike information criterion" (AIC) was used to judge the optimal lag order since it delivers more accurate and consistent results and information than other criteria. The optimal lag is determined by reducing the AIC.The ARDL model relies heavily on determining the optimal Lag lengths. The results of the lag order selection are shown in Table 4. Four out of five criteria for conducting co-integration show a lag length of two.

Table 4 – Lag length

Lag	LogL	LR	FPE	AIC	SC	HQ
0	69.9595	NA	1.68e-08	-3.711969	-3.489777	-3.635268
1	366.6220	491.6122	3.10e-15	-19.23554	-17.90239*	-18.77534
2	405.3018	53.04655*	1.56e-15*	-20.01724*	-17.57312	-19.17353*
3	430.0551	26.87509	2.04e-15	-20.00315	-16.44807	-18.77594

* indicates lag order selected by the criterion .LR: sequential modified LR test statistic (each test at 5% level). FPE: Final prediction error. AIC: Akaike information criterion. SC: Schwarz information criterion. HQ: Hannan-Quinn information criterion.

4.4. Bound Test Cointegration

In this step, the bound test is used to see a co-integration relationship between Algeria's ecological footprint, financial development, human capital, and gross domestic product. The F-statistic value was compared to the critical limits test value supplied by Narayan (2004): (a) restricted intercept and no trend, and (b) constrained constants and trend.

Table 5 – Bound test for the existence of a long-run relationship

Test statistics	**Value**	**Number of covariates (k)**
F-statistics Bounds of the critical value	7.58	4
Level of significance	Lower bound	Upper bound
10%	2.2	3.09
5%	2.56	3.49
2.5%	2.88	3.87
1%	3.29	4.37

The F-statistics equals 7.58, more than the upper bound maximum critical value (i.e., 3.49). As a result, the null hypothesis is rejected, and the alternative hypothesis is accepted. It signifies that there is a long-run relationship between the study variables. Long-term estimates are then made based on these findings. The long-run impacts of HC, FD, and GDP on the EFP are presented in Table 7.

We accomplished the test by checking the F-statistic value with the fundamental limits test value given by Narayan (2004) for just two cases: (a) limited intercepting and not trend, whereas (b) limited constants and trend.

The literature presents numerous econometric methodologies to study the long-run co-integration connection between the variables. Johansen co-integration is frequently used and favoured over other approaches. Since it can handle modest sample size bias and give more than one co-integration relationship, it needs all variables to be integrated in the same order. Pesaran and Smith (1995) and Pesaran et al. (2001) Autoregressive Distributed Lag (ARDL) approach address the issue of Johansen co-integration. In this work, the ARDL approach was employed to conduct multivariable co-integration among the study variables. The ARDL bound test offers additional benefits compared to other multivariate co-integration methods (Pesaran et al., 2001b). Adding a lag to our variables makes it feasible to prevent small observations' endogenous and more reliable concerns. It is allowed to combine integrated variables of the same or different order, as long as the order of integration does not exceed one. (Integrated of order zero I(0) or order one I(1) or mixed).It is possible to estimate both short-term and long-term coefficients simultaneously. And compute the speed of adjustment to the equilibrium level (Nkoro & Uko, 2016). Residual correlation is minimized due to proper lag selection, and therefore the endogeneity problem is reduced (Ali et al., 2016).

4.5. Short-run results

In the short term, The ARDL results from model 1 depict that Gross domestic product has a significant and positive influence on environment degradation. Besides, financial development leads to inhibit pollution emissions. Human development also has been statistically significant and negatively associated with an ecological footprint in Algeria. The ECM value is negative at 5%, indicating how the variables converge to their equilibrium path.

Table 6 – Short-run coefficients

Variables	Coefficient	Std. Error	t-Statistic	Prob.
FD (credit size)	-1.3606	0.7808	-1.7426	0.0000
GDP per capita	2,6715	0,4174	6,3991	0,0007
HC (education)	-1,2801	0,3032	-4,2218	0,0056
ECT ()	-0,3373	0,0519	-6,5036	0,0006
R squared	0,9492	Adj R squared	0,8377	
F statistic	8,5104	Prob F statistic	0,00065	

For our Model, the predicted ECT(t-1) (also known as the speed of adjustment) equal to -0,337 is negative and significant (Table 6). These findings show that the variables have a long-term link. When ecological footprint deviates significantly from its equilibrium level, it adjusts by about 33.7% in the first period (year). It takes around three periods to reach the equilibrium level (year). In a shock to ecological footprint, the time it takes to reach equilibrium is quick and considerable.

4.6. Long-run results

After confirming the integration order, the paper then estimates the long-term effects of economic growth, financial development, and human capital on Algerian's ecological footprint from 1980 to 2017. Table 7 displays the long-run estimation results.

Our finding shows that credit size and education coefficients are negative and significant, whereas the economic growth coefficient is positive and significant.

The results presented in Table 7 indicate that economic growth has a positive and statistically significant impact on the ecological footprint. This shows that increasing levels of economic development contribute significantly to environmental degradation. The results conclude that a 1% increase in economic growth is associated with a 1.63% increase in the ecological footprint.

The results indicate that credit size is negatively linked with ecological footprint; a 1% increase in credit size mitigates pollution by approximately-0.325% at a 5% significant level .These results indicate that Algeria is adopting an environmentally friendly banking sector, which helps improve environmental quality. This also means that Algeria does not provide financing that harms the environment. Another reason behind this result is that most banks' financing is directed to individuals in consumer loans.

Furthermore, the findings indicate that an increase in education substantially affects ecological footprint; a 1% increase in HC contributes to improving the environment approximately by 0.475% at the 5% level of significance.

Table 7 – Long run coefficients

Variables	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-13.37758	1.647791	-8.118491	0.0000
FD (credit size)	-0,3255	0.155356	-2.095683	0.0468
EG (GDP p.c.)	1,6303	0.213772	7.626467	0.0000
HC (education)	-0,4752	0.201966	-2.353237	0.0271

4.7. Granger causality analysis

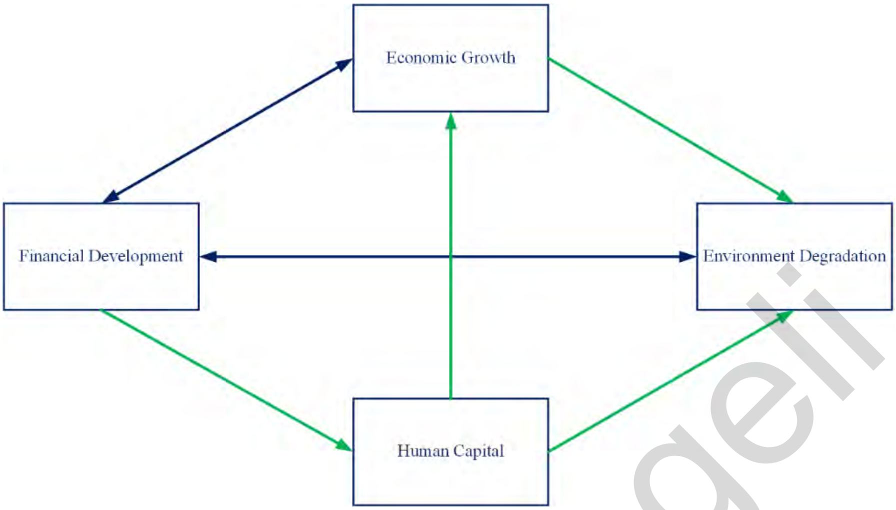
The results of this study were further evaluated using the Granger causality test to determine the direction of long- and short-run causalities in the ecological footprint, financial development, Human capital, and economic growth nexus. Within the vector error correction, we investigated the Granger causality model. Granger causality test is used to look into the direction of the variables' causality. To confirm the relationship between the variables, the paper conducts a Granger causality analysis (Engle & Granger, 1987) with the null hypothesis that the relationship is not causal. The results revealed that economic growth and financial development have a bidirectional causal relationship (table 8, figure 1).

The results indicated the existence of a one-way causality from education to ecological footprint, and from credit size to EFP. Also, there is a two-way causality between financial development and ecological footprint in Algeria. In addition, there is a two-directional causality relationship between credit size and growth. And one-directional causality relationship from education to growth. This result suggests that credit size and education in Algeria are expected to play an important role in the improvement of environment.

Table 8 – Granger causality test

Null Hypothesis	F-Statistic	Prob
GDP does not Granger Cause EFP	5.58949	0.0239
EFP does not Granger Cause GDP	0.00357	0.9527
HC does not Granger Cause EFP	2.86229	0.0998
EFP does not Granger Cause HC	0.13557	0.7150
GDP does not Granger Cause FD	2.89859	0.0978
FD does not Granger Cause GDP	5.50419	0.0249
HC does not Granger Cause FD	2.13826	0.1528
FD does not Granger Cause HC	4.42143	0.0430
FD does not Granger Cause EFP	8.27657	0.0083
EFP does not Granger Cause FD	2.97923	0.0726
HC does not Granger Cause GDP	5.87036	0.0209
GDP does not Granger Cause HC	0.08582	0.7713

Figure 1 – The plot of the Granger causality test



4.8. Robustness Check

Before ending the presentation of results, it is critical to test the sensitivity of long-run parameters acquired by ARDL. To determine the robustness of the estimates, we re-estimate the Model (4) using DOLS developed by (Stock & Watson, 1993).

The DOLS employs a parametric approach to estimate equation coefficients in a model with integrated variables (Masih & Masih, 1996). Simultaneous and small sample biases are addressed in this approach (Kurozumi & Hayakawa, 2009). Even when there is an endogenous problem, least-squares estimates can construct unbiased and asymptotically efficient DOLS estimators. Additionally, the parameters control the autocorrelation and residual non-normality that may arise (Herzer & Nowak-Lehnmann D., 2006).

Table 9 – Results of DOLS

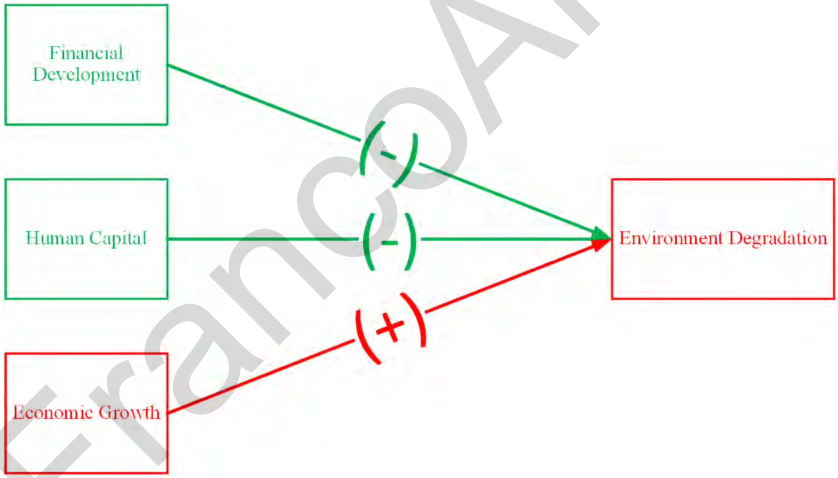
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
FD (credit size)	-0.875630	0.196780	-4.44979	0.0003
GDP per capita	0.970070	0.288827	3.35865	0.0035
HC (education)	-0.453261	0.246860	-1.83610	0.0829
C	-8.652800	2.131227	-4.06000	0.0007
R-squared	0.9490			

Table 10 summarizes the findings of this DOLS estimation. According to the results, economic growth has a positive impact on the ecological footprint. However, credit size and education have a positive effect on environmental quality. These results produced identical results as the previous ones, confirming the consistency and robustness of the ARDL results.

5. Conclusions and policy implications

This article examines the joint effect of financial development and human capital onthe ecological footprint in Algeria. The Preliminaryfindings demonstrated the existence of co-integration between our variables. Moreover, the ARDL findings show that economic growth contributes considerably to Algeria's environmental degradation; this is in line with the previous studies, i.e., to Danish et al. (2019); S. Nathaniel & Khan (2020); S. P. Nathaniel (2021c); Udemba (2020). Furthermore, we find a positive impact of financial development (credit size) and human capital (education) on environmental degradation (ecological footprint), similar to many studies (Majeed & Mazhar, 2019; Pata et al., 2021; Usman & Hammar, 2021; Zafar et al., 2019). Below the graphical findings of our study.

Figure 2 – The plot of the our findings



The findings are highly acceptable when arguing that human capital reduces environmental damage. That is, the effect of Human capital is separated from economic growth (as Granger causality shows above), even though economic growth impacts environment degradation (Ahmed, Asghar et al., 2020; S. P. Nathaniel, 2021a, 2021b). This remark further confirms the finding reached by (Shujah-ur-Rahman et al., 2019) that the significant effects of human capital are considered negative on the ecological footprint. In addition, the free education system boosted the number of students and consequently enhanced environmental consciousness among Algerians.

Second, when we claim that financial development improves the environment while economic growth is harmful, it's a weird outcome! Still, this outcome is similar to (Ahmed et al., 2019; Akinsola et al., 2022; Uddin et al., 2017). This does not prevent us from pointing out that the Algerian economy depends on oil exploitation, the leading industry with the highest added value, and its export, which has no significant local environmental effect (it may have a transfer effect on other countries). Moreover, SMEs are the primary company kind (most of them have a negligible impact on the environment). According to Talukdar & Meisner (2001), a stable financial sector may help enterprises implement environmentally responsible investments. Furthermore, Algeria has traditional agriculture, and thus its financing is considered environmentally friendly.

6. Conclusion and policy implications

This study investigated the effect of financial development, human capital, and economic growth on environmental degradation in Algeria, covering the period 1980-2017. We employed the ARDL model after the stationarity tests for the variables and the bound test. We get the long-run and short-run parameters.

The main findings that emerged from the study are summarized as follows: we concluded that there is a long-run relationship between economic growth, human capital, financial development one one side, and environmental degradation measured with the ecological footprint on the other side. Empirical test results indicated that human capital and financial development reduce the ecological footprint in Algeria. On the other side, economic growth increases the ecological footprint.

Empirical findings on the effects of financial development and human capital on the ecological footprint in Algeria provide two valuable policy implications for achieving green and sustainable economic growth.

First, financial development positively impacts the environmental quality in Algeria's short and long term. Developing the financial sector in Algeria is a challenge for Algerian authorities (Chiad, 2021). Therefore, the need to use the financial resources arising mainly from the hydrocarbon sector towards supporting technological innovations, low-carbon technologies, rising spending on research, and development in energy conservation .To improve energy efficiency, the Algerian government must enhance the efficiency of the financial sector and improve financing mechanisms for green projects.

Second, the findings suggest that human capital can limit environmental degradation. Therefore, the Algerian government can count on improving its human capital to improve environmental quality in the long term. Thus, the investment must be made to improve human capital, increase allocations for education, and train the workforce with modern skills, especially in environmentally friendly technologies.

Annex 1. Diagnostic tests

The diagnostic tests were run to rule out any problems with heteroscedasticity, abnormality, or serial correlation. Obtained results of the heteroscedasticity test show that the current Model has no issues with heteroscedasticity. The Breusch-Pagan-Godfrey test is used to determine the presence of heteroscedasticity. The p-value is more than 5% significant levels, so we cannot reject the null hypothesis of Homoskedasticity.

The serial correlation LM test evaluates the strength of our variables' associations and neglecting it will have a detrimental impact on the outcomes of our model estimations .The serial correlation test findings in Table 5 show that we have accepted the null hypothesis of no correlations among residuals.

The ARDL model includes a series of diagnostic tests to determine whether the estimated error correction model meets these assumptions. (1) LM Test: To see if the residuals are serially associated, use the Lagrange Multiplier test.(2) ARCH Test: To determine whether the estimated Model is heteroscedastic or homoscedastic, use the heteroscedasticity test and the autoregressive conditional heteroscedasticity (ARCH) test. (3) The residual normality test by Jurque Bera. (4) For a functional form and misspecification issue, we use the Ramsey RESET test. (5) For parameter stability over time, use the CUSUM test and the CUSUM of squares test.

Table 10 – Diagnostic tests

Sensitivity analysis			
R square	0.9645		
F statistic	93.576		
Prob (F statistic)	[0.0000]		
Robust check			
Ramsey reset		1.2604	[0.2202]
LM test		0.3584	[0.783]
ARCH test		1.2466	[0.3160]
Breusch-Pagan-Godfrey		1,104	[0.3980]
Jarque–Bera		0,3073	[0.8575]
CUSUM and CUSUMsq	Stable		

Values in parenthesis are probabilities

We used the CUSUM tests to predict whether or not a long-run relationship exists. This test performs a recursive calculation of the regression coefficients and associated residuals at defined thresholds. It usually defines threshold quantities for graphing to demonstrate various recursive statistics regarded as functions of ordered transitions of variables. It is primarily used in practice to determine thresholds.

Figure 3 – The cumulative sum (CUMSUM) results. The red line represents the 5% level of significance

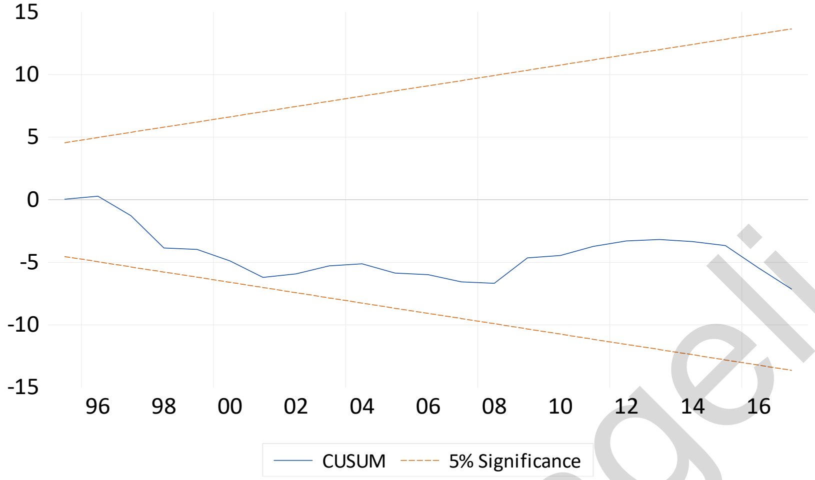
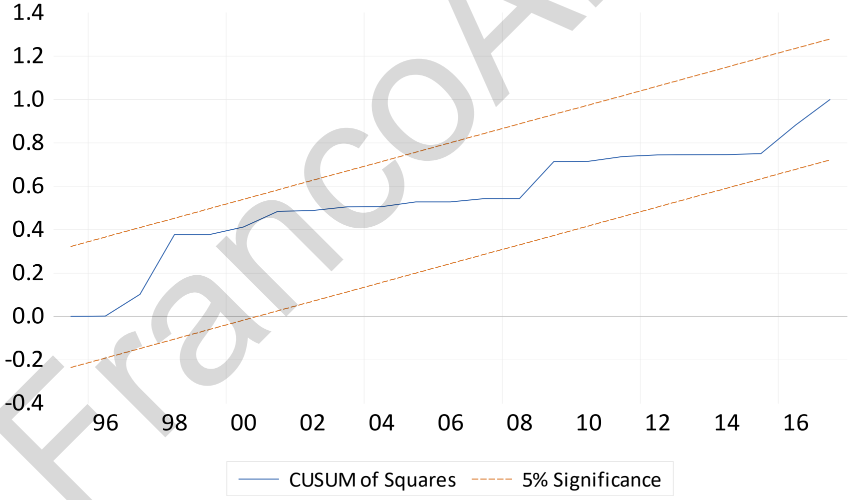


Figure 4 – The cumulative sum of square (CUMSUM2) results. The red line represents the 5% level of significance



Stability tests were also carried out using the 'cumulative sum' (CUSUM) and 'CUSUM square point' to guarantee that long-term and short-term parameters were stable (see Fig. 2). At the 5% significance level, all values are inside the sharp boundaries. During 1980-2017, the short- and long-term parameters stability was confirmed.

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