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ASSESSMENT OF THE IMPACT OF POPULATION DENSITY, HUMAN RESOURCE QUALITY, AND ECONOMIC DEVELOPMENT ON ENVIRONMENTAL DAMAGE

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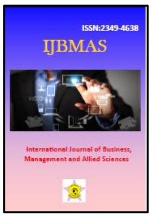


ABSTRACT

The information obtained mainly from environmental monitoring networks is transformed into its use within the political process, presenting synthetic indicators and indices whose direct users are decision-makers and the general population. Due to their relevance and importance, the development of indicators has been promoted rapidly and extensively throughout the world, combining a clear scientific basis with an expressly recognised social and political content. Environmental degradation is still a problem, along with increasing economic development. Initiatives to enhance environmental quality are essential. This study seeks to ascertain the impact of economic development on environmental degradation. Furthermore, the caliber of human resources and population density may serve as additional explanatory variables associated with environmental degradation. This study uses panel data regression analysis from 2013-2021 in 3 provinces of Libya. The study results indicate that the Environmental Kuznet Curve (EKC) hypothesis is not proven because GDP as an indicator of economic development has a negative and significant effect on Environmental Damage. In contrast, the quadratic of GDP has no significant effect. Population density exerts a detrimental and significant influence on environmental degradation. In addition, improving the quality of human resources has been shown to reduce Environmental degradation in Libya. From the current research work, it is possible to define future challenges or points to be addressed in the environmental impact assessment process about the complex problem of indicators and the information that supports them, such as the adjustment of existing legislation and regulations, strengthening of environmental monitoring networks; certification of the consultancies that issue the technical reports; improvement of its economic status and human resources;

transparency of information and accountability, including a transparent, clear and effective mechanism for public consultation; methodological and technical unification, with the possible development of specific guides for different types of work; formation of an inter and intra-institutional information system.

Keywords: Population density, environmental impact, macroeconomics, statistical study, Libya

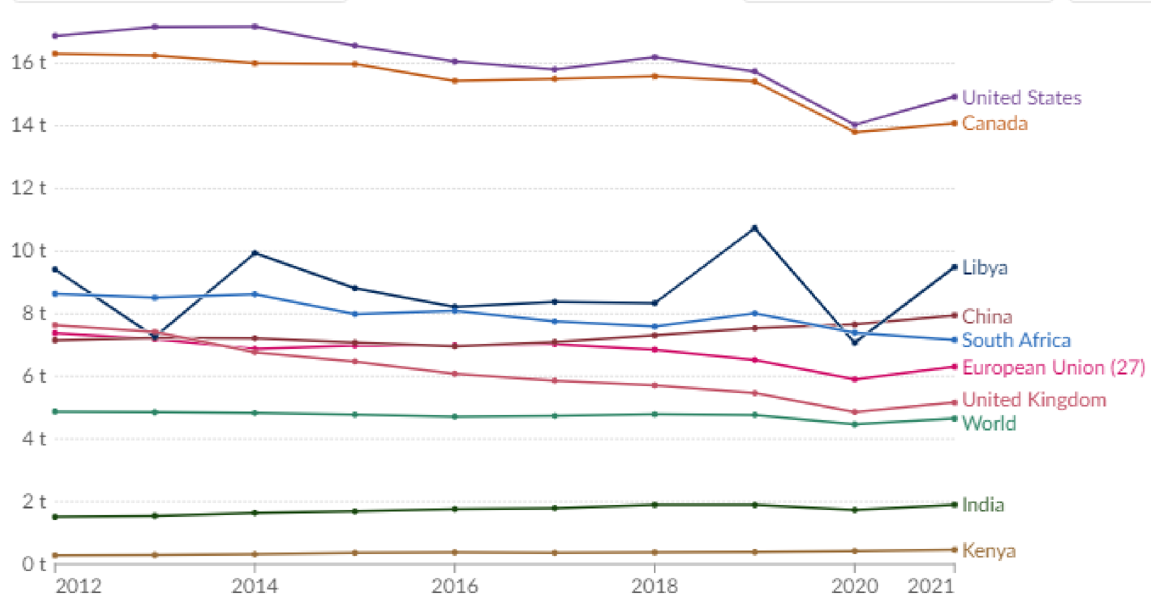
1. INTRODUCTION

Development is very important for every country. Development in terms of the economy is one of the things that must constantly be developed because it concerns the livelihood of many people. However, amid the current boom in economic development, there is a dilemma concerning economic development on the one hand and environmental sustainability on the other [1].

The classical theory of economic growth highlights the important aspects of two main factors that have a major impact on the economic growth of a country or region. First, population growth can positively contribute by increasing the number of workers and expanding the market [2-3]. Second, technological advances play a vital role in increasing the productivity and efficiency of the production process, which in turn becomes a strong driver of economic growth [4]. According to the classical theory of economic growth, economic growth will reach a saturation point along with the increasing population and limited resources. Population growth will increase the demand for goods and services, while increasingly limited resources will limit the economy's ability to meet this demand. The classical theory of economic growth is simple but is still relevant today. This theory provides an important understanding of the factors that influence economic growth in the long term [5].

Population density is a measure of how many people live in an area. This measure is calculated by dividing the population by the area. The units used are usually people per square kilometer. This concept is an important indicator that reflects the disparity or difference in resources owned by a region. Regions with more abundant resources, be it natural resources such as fertile land, mineral wealth, or educated and skilled human resources, tend to attract more people to live there. This leads to a higher population density in the region [6]. Thus, understanding population density allows the government to identify areas requiring more attention to achieve equitable development. These efforts may include providing basic infrastructure, investing in human resources, and increasing access to health and education services. By paying attention to population density, the government can direct more appropriate policies to achieve more equitable development throughout the country or region. Population density is a measure of how densely people live in an area. Population density can be quantified through various metrics, including the number of individuals per square kilometer, per sub-district, and per village. Population density is one of the important factors that affects various aspects of social, economic, and environmental life. Experts have proposed various theories to explain the relationship between population density and these factors [7].

The 2020 Environmental Performance Index (EPI) shows Libya's environmental quality is ranked 123rd out of 180 countries [8]. In addition, based on data collected by the Potsdam Institute for Climate Impact Research (CIR), in 2015, Libya's greenhouse gas emissions reached 2.4 billion tons of CO2 equivalent (GtCO2e). Per capita emissions in that year reached 10.2 tons of CO_2, higher than the global average (7.0 tons of CO_2) and the average of several other countries such as Canada, the USA.



Per capita CO_2 emissions (Source: https://ourworldindata.org/co2/country/libya)

Libya is one of three developing countries with the highest CO2 emission reduction rate from 2012 to 2012 [9]. In the Paris Agreement, Libya is committed to reducing its greenhouse gas emissions by 29 % to 41 % (through international cooperation) by 2030. Therefore, various environmentally conscious efforts and policies are needed to realise it.

One of the indicators that can be used to measure environmental quality in Libya is the Environmental Quality Index (IKLH) compiled by the Ministry of Environment and Forestry/Dissert. In general, IKLH is compiled with a combination of the Environmental Quality Index (EQI) concept and the Environmental Performance Index (EPI) concept [10]. In addition, IKLH is calculated at the provincial level, so it can be used to see more details about the environmental quality of each region in Libya.

The condition of environmental quality in Libya is quite diverse. Libya's environmental quality based on IKLH was Nationally Fairly Good in 2019. The IKLH value in that year was 66.55, a decrease of 5.12 points from 2018. Meanwhile, if we look at it in more detail, all provinces of Libya have IKLH values that are lower than the national IKLH. In fact, during the second quarter of 2021, Libya contributed 58.55 % of the Libyan economy. Seeing these two things, it is interesting to observe the pattern of the relationship between economic activity and the environmental effects produced in the Tripolitania region. An environmentally friendly economic development policy is hoped to be formulated from this pattern.

The Environmental Kuznet Curve (EKC) hypothesis typically illustrates an inverted U-shaped relationship between economic development and environmental degradation. Latifa et al. (2013) [11] propose that environmental degradation escalates in correlation with rising per capita income during the initial phases of development characterized by industrialization. This usually occurs in developing countries that prioritise economic growth over environmental protection. In the next stage, marked by increasingly advanced economic development and increasing environmental awareness, increasing per capita income will reduce environmental damage.

Kar, A. K. (2023) [23] conducted research related to the EKC hypothesis. The study used CO2 emissions as an indicator of environmental damage from 1980-2012. The study found a relationship between economic growth and environmental damage. In addition, the EKC hypothesis is also proven in the long term but cannot be explained in the short term.

Saleem et al. (2018)[13] also researched the EKC hypothesis in The Next Eleven (N-11) countries from 1975 to 2015. In their research, the EKC hypothesis was proven in the CO2 indicator. In addition, they also added the population density variable as an explanatory variable. The results show that population density significantly affects the increase in CO2 and greenhouse gases (GHG). Related research was also conducted by Nuansa, et al (2014) in 33 provinces in Indonesia from 2011 to 2016. In the study, the Human Development Index (HDI), an indicator of the quality of human development, was added as an explanatory variable. The results show that human development has a significant role in explaining the environmental damage that occurs.

The explanation above shows the relationship between population density and the quality of human development in explaining the phenomenon of environmental damage. Both of these things have been empirically proven to have a role in changes in environmental quality. Thus, both can be alternative policies to create environmentally friendly economic development.

Studies related to environmental-based development in Libya [15-16] are still limited, so information on environmental-based development in this region is difficult to obtain. Therefore, an analysis of economic development and its effects on the environment in Libya using the EKC approach is very important. In addition, the variables of human development quality and population density are added as explanatory variables to provide other related phenomena.

2. METHODOLOGY

This study uses panel data covering 3 provinces in Libya from 2013 to 2021. The design of this study uses explanatory quantitative research. This is intended to determine the effect of GDP, HDI, and population density on IKLH as an indicator of environmental damage. The variables and data sources used are as follows:

Table 1. variables used in the current investigation

No.	*Variable*	*Unit*	*Source*
1	Environmental Quality Index	Points	*Ministry of Environment and Forestry*
2	Gross Regional Domestic Product	Billion	Central Statistics Agency
3	Human Development Index	Points	Central Statistics Agency
4	Population Density	Density/km^2	Central Statistics Agency

Before conducting the regression analysis, the author rescaled the IKLH variable, which means that the higher the value, the lower the level of environmental damage. This was done to adjust the meaning of the environmental damage indicator in the EKC hypothesis, namely that the higher the value of the environmental damage indicator, the higher the level of environmental damage. Rescale was carried out using the following formula:

$$\mathrm{RIKLH} = (100 - \mathrm{IKLH_{it}})\ (\mathrm{Eq.}\ 1)$$

In addition, a quadratic model was used to prove the existence of the EKC hypothesis. Thus, the panel regression model used in this study is as follows:

$$\mathrm{RIKLH_{it}} = \alpha + \beta_1\, \mathrm{PDRB_{it}} + \beta_2\, \mathrm{PDRB}_{it}^2 + \beta_3\, \mathrm{IPM_{it}} + \beta_3\, \mathrm{KP_{it}} + e_{\mathrm{it}} \quad (\mathrm{Eq.}\ 2)$$

where:

$\mathrm{RIKLH_{it}}$ = Reverse of IKLH of province i in year t

$\mathrm{PDRB_{it}}$ = GDP of province i in year t

$\mathrm{IPM_{it}}$ = HDI of province i in year t

KP_{it} = Population density of province i in year t

α = intercept

$\beta_1\ \beta_2\ \beta_3\ \beta_4$ = coefficient x

e_{it} = error term of province i in year t

where the error term (e_{it}) can be decomposed into the form:

$$e_{it} = u_i + v_{it} \quad \text{(Eq. 3)}$$

where u_i is the individual effect and v_{it} is the residual effect.

3. RESULTS AND DISCUSSION

Selecting the Appropriate Model

3.1. Suitability Test between *Common Effect Model* (CEM) and *Fixed Effect Model* (FEM)

The first stage was to test the model's suitability using the Chow test. This test is used to compare the suitability of CEM and FEM.

The Chow Statistical Test yielded a probability value of 0.0158. Consequently, at a significance level of 5%, it can be concluded that the FEM model outperforms the CEM model.

Table 2. Chow statistical test results.

Test effect	Statistics	D_f	$Prob.$
$Cross - section\ F$	3.1702	5.37	0.0158
$Cross - section\ Chi - square$	16.5024	5	0.0053

3.2. Suitability Test between Common Effect Model (CEM) and Random Effect Model (REM)

The next stage is to test the suitability between REM and FEM using the Hausman test. Based on the Hausman Statistical Test, a probability value 0.3359 is obtained. With a significance level of 5 %, it can be concluded that the REM model is better than the FEM model.

Table 3. Results of the Hausman statistical test

Test Summary	χ^2 −statistic	$\chi^2 - D_f$	Prob.
$Cross - section\ random$	45.573	4	0.3359

The results of the two tests indicate that the REM model is better to use than the CEM model or the FEM model. The next step is to conduct a classical assumption test consisting of a normality test and a non-multicollinearity test for the REM model obtained. The REM model uses the Generalized Least Square (GLS) estimator, which can accommodate heteroscedasticity and autocorrelation [17]. Thus, the homoscedasticity and non-autocorrelation tests do not need to be performed.

Assumption Test

To ensure that the resulting estimator meets the classical assumption rules, the author conducted the following assumption tests:

3.2.1 Normality Assumption Test

The Jarque-Bera normality test (Figure 1) yielded a p-value of 0.690072, which exceeds the 5% significance threshold. Consequently, at the 5% significance level, it can be inferred that the normality assumption is satisfied.

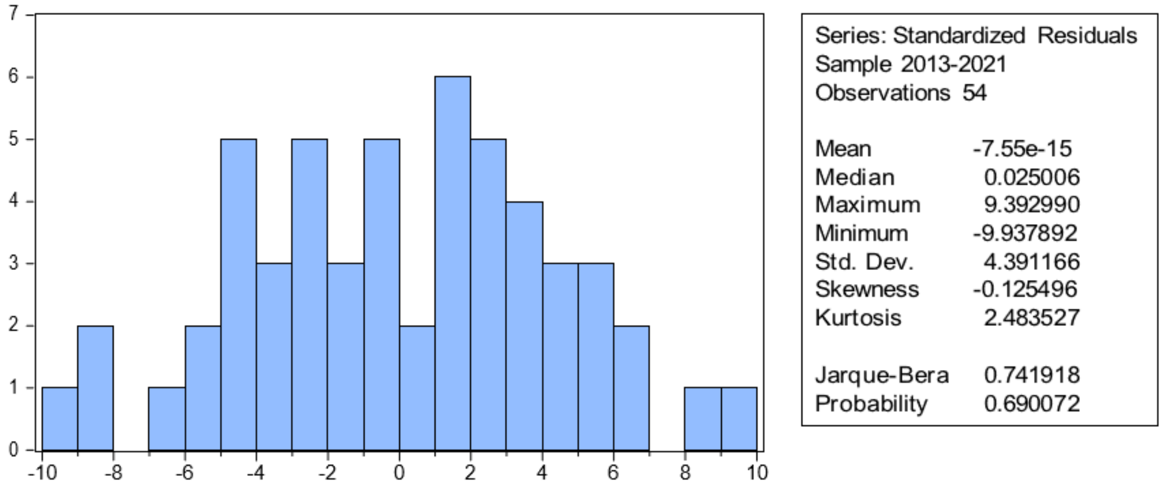


Figure 1. Normality Assumption Test with Jarque-Bera Test.

3.2.2. Non-Multicollinearity

Then, the non-multicollinearity assumption test was conducted by looking at the Pearson correlation coefficient between the independent variables. Table 4 shows that the Pearson correlation value (ranging between -0. 0.7659 and 0.6492) is smaller than 0.9, meaning there is no correlation between the independent variables in the model. Thus, the non-multicollinearity assumption is met.

Table 4. Pearson Correlation between independent variables.

	$\mathbf{DEVL_{NPDRB}}$	$\mathbf{DEVL_{NPDRB^2}}$	IPM	$\mathbf{LOG(}K_P\mathbf{)}$
$\mathbf{DEVL_{NPDRB}}$	1	-0.7659	-0.2859	0.3041
$\mathbf{DEVL_{NPDRB^2}}$	-0.7659	1	0.559	-0.0657
IPM	-0.2859	0.559	1	0.6492
$\mathbf{LOG(}K_P\mathbf{)}$	0.3041	-0.0657	0.6492	1

3.3. Final Model Formed and Interpretation

The final model achieved satisfies the assumptions of normality, homoscedasticity, non-multicollinearity, and non-autocorrelation applicable to panel data regression. Consequently, the model is pertinent to elucidating the phenomenon of environmental degradation in Libya. The environmental degradation model established in Libya is as follows:

Table 5. Final Modelling Results

Variable	$Coefficient$	$Std. Error$	$t-Statistic$	$Prob.$
C	36.7071	18.2097	1.9352	0.0473
$\mathbf{DEVL_{NPDRB}}$	-3.323	1.6169	-1.9729	0.0434
$\mathbf{DEVL_{NPDRB^2}}$	0.7315	1.3362	0.5256	0.5631

IPM	-0.9126	0.3529	-2.4826	0.0122
LOG(K_P)	9.9807	1.6013	5.9836	0
Weighted Statistics				
R^2	0.4638	$F-statistic$		10.9923
$Adjusted\ R^2$	0.4233	$Prob(F-statistic)$		0

Alternatively, if written in a mathematical equation, it is as follows:

$$\text{Environmental damage} = (36.7071+ u_i) - 3.323\,PDRB + 0.7315\,\mathbf{PDRB^2} - 0.9126\,IPM + 9.9807\boldsymbol{K_P}$$

The results of the overall test using the $F\ test$ obtained a p-value that was smaller than 0.05. Therefore, at a significance level of 5%, it can be concluded that at least one independent variable significantly affects environmental damage in Libya. When viewed partially, the GDP and HDI variables positively and significantly affect environmental damage. Furthermore, the population density variable negatively and significantly affects environmental damage. Meanwhile, the quadratic variable of GDP does not have a significant effect.

The estimation results obtained produce an R^2 value of 0.4638. Based on this value, it can be said that 48 % of the diversity of environmental damage in Libya can be explained by the independent variables contained in the model. The remaining 52% is the contribution of other variables that have not been included in the model. This value is quite good, considering that the best model in this study is REM.

The regression results show that the GDP variable has a negative and significant effect on changes in environmental damage at a significance level of 5 %. The coefficient value of -3.462 indicates that every 1 % increase in GDP above the average will cause environmental damage to decrease by 3.462 points, assuming other variables are constant.

Moreover, the regression analysis indicates that the quadratic variable of GDP does not exert a significant influence on variations in environmental damage at a 5% significance level. The EKC hypothesis is validated if the per capita income indicator exerts a positive influence while its quadratic counterpart demonstrates a negative effect. Both are statistically significant concerning the environmental damage indicator. This study concludes that the EKC hypothesis is not substantiated in the context of the Libyan economy. This finding corroborates research [18], which demonstrated that the Environmental Kuznets Curve (EKC) hypothesis was validated solely in high-income nations, excluding developing countries in Africa.

Although the regression results show that increasing GDP can reduce environmental damage, the direction of the quadratic of the GDP variable shows a positive number. This shows a potential for an increase in environmental damage in line with economic development in Libya. Therefore, for economic development to grow in line with improvements in environmental quality, an economic transformation towards an environmentally friendly economy is needed [19].

Furthermore, the regression results show that the HDI variable has a negative and significant effect on changes in environmental damage. The coefficient value of -0.950637 indicates that every 1-point increase in the HDI will cause environmental damage to decrease by 0.950637 points, assuming other variables are constant. This aligns with research conducted by (Arango et al., 2020) [20]. The study stated that the HDI has a significant effect on reducing environmental damage.

Li et al (2021) [21] found something similar. In their study, it was found that countries with high HDI have low levels of environmental damage. Likewise, countries with low HDI have the potential for high environmental damage. Therefore, improving the quality of human resources, especially in terms of education, can be a solution to reduce the impact of environmental damage.

Finally, the regression results show that population density has a positive and significant effect on changes in environmental damage at a significance level of 5 %. The positive effect shows that the denser an area is, the higher the level of environmental damage. The coefficient value of 10.39658 indicates that every 1 % increase in population density will cause environmental damage to increase by 10.39658 points, assuming other variables are constant. This aligns with the research by Wafiq, et al., 2021 [22]; Han et al (2019) [23]. Their research found evidence that the population density variable significantly affects increasing environmental damage.

Lambin (2011) [24] stated that in the early stages of economic development (developing countries), it tends to be concentrated in small places. The same is true for Libya, the centre of Libya's economy. In addition, rapid population growth tends to result in extensive environmental damage, forest encroachment, deforestation, depletion of firewood, soil erosion, unsafe water, air pollution, and city congestion. Therefore, control over population distribution and population growth rates can be a solution to reduce the impact of environmental damage that occurs in Libya.

4. CONCLUSION

The results of this study indicate that the EKC hypothesis has not been proven in the Libya economy throughout 2013-2021. When viewed from the influence of each independent variable, the GDP and HDI variables significantly reduce environmental damage. On the other hand, the population density variable has the opposite effect.

Although the GDP variable significantly reduces environmental damage, the quadratic direction of the GDP variable shows a positive number. Therefore, the government must continue to increase the implementation of environmentally friendly economic activities through economic transformation, the use of green technology, the implementation of carbon pricing and other related policies. In addition, improving the quality of human resources and controlling population distribution can also be a solution to reduce the impact of environmental damage due to economic activities in Libya.

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