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POPULATION, ENVIRONMENT AND CLIMATE CHANGE:

ENVIRONMENTAL QUALITY IN AFRICA: IS THE DEMOGRAPHIC DIVIDEND AN ASSET?

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Abstract

Deforestation in Africa poses significant challenges to environmental quality and sustainable development. This article examines the relationship between deforestation and environmental quality in Africa, focusing on whether the demographic dividend can be used as an asset to address this issue. By exploring the potential impact of the demographic dividend on deforestation trends and its implications for environmental policies and economic development, this study aims to shed light on the complex interplay between population dynamics, economic growth and environmental sustainability in the African context. Accordingly, using econometric methods of pooled mean group, fixed and random effects on a panel of 44 African countries for the period 1975-2021. The results suggest that the demographic dividend contributes to the degradation of environmental quality in Africa. The implications of this study for economic policy suggest that addressing the underlying drivers and challenges associated with agricultural practices is essential to minimizing deforestation for environmental sustainability in Africa to achieve the Sustainable Development Goals (SDGs).

Key words: Deforestation, Demographic dividend, Fixed effect, Environmental quality, Pooled mean group.

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1. Introduction

The discussion surrounding the relationship between income and the environment, similar to the impact of the demographic dividend on environmental quality in Africa, is currently the subject of growing controversy. Primarily, the elements linked to population dynamics intersect with environmental concerns (Xiao et al., 2022). Secondly, the ability of demographic variables to exacerbate or mitigate the impacts of climate change has prompted dialogues on harnessing the demographic dividend to address environmental obstacles (Koutika et al., 2022). Thirdly, rapid urbanization and the resulting changes in consumption patterns have prompted discussions on how demographic change can affect environmental quality at global, regional and local scales (Olorunfemi et al., 2022). This debate underlines a wider recognition of the need to integrate demographic considerations into environmental policies and strategies. Essentially, a holistic approach that takes into account both demographic transformations and environmental sustainability is imperative to achieve a balance between economic progress and environmental preservation in Africa (Asongu et al., 2020; Nguea, 2023). By recognizing deforestation as an indicator of environmental quality (Cropper and Griffiths, 1994) and understanding the potential of the demographic dividend as an asset, it becomes clear that integrating demographic dynamics into comprehensive environmental policies and strategies is essential to achieving sustainable development goals in Africa.

According to FAO findings (2021), 26% of Africa's land area is designated as forested, with the continent home to almost 43 billion trees. Every year, almost 4 million hectares of African forests are threatened with destruction, a rate almost twice as high as the global average. At the same time, 66% of Africa is classified as arid. The arid climate prevailing in these desert zones results in tree cover representing around 17% of the country's total surface area. Despite an overall reduction in deforestation rates in recent times, Africa continues to experience an increase in woodland loss, compromising the resilience of the continent's ecosystems in the face of climate change. There is no doubt that forests play a central role in maintaining environmental integrity, serving as vital watersheds, protecting land from soil erosion, regulating local climates and capturing greenhouse gases (Martina Igini, 2022; Sacande et al., 2022).

Deforestation in Africa is an urgent problem that has a significant influence on environmental quality and the promotion of sustainability. The depletion of forest resources not only leads to the eradication of natural habitats and the reduction of biodiversity, but also plays a role in soil deterioration, limited water availability and the impacts of climatic variations. Given the complex relationship between environmental adversities and demographic dynamics, the notion of demographic dividend is gaining in importance in the African sphere. The term demographic dividend refers to a phase in which the proportion of a country's working-age population exceeds that of the dependent population, thereby fostering the potential for economic expansion and progress (Bloom et al., 2003). By 2021, Africa's population was estimated at around 1.2 billion. Africa's annual population growth rate peaked at 3% in 1978 and remained at levels above 2.8% throughout the 1980s. Since the 1980s, Africa has become the fastest-growing region in the world. According to forecasts, Africa's population will almost double, exceeding 2 billion by the end of the 2040s (WPP, 2022). The region's population is growing at an annual rate of 2.5%, the highest of the eight regions, and more than three times the world average of 0.8% per year. With average fertility rates expected to reach nearly 3 births

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per woman by 2050, Africa is set to contribute more than fifty percent of global population growth between 2021 and 2050 (WPP, 2022).

Numerous studies have highlighted the complex nature of the relationship between the demographic dividend and environmental quality. Nevertheless, a crucial aspect of these discussions acknowledges the existence of inclinations that encompass both pessimistic and optimistic perspectives. Clydesdale (2018) postulates that these dialogues are centered on the Kuznet Environmental Curve (ECK) hypothesis regarding deforestation. Thünen (1826) asserts that population growth and urbanization lead to an increase in demand for arable land, resulting in the transformation of forests into agricultural areas. Similarly, increased labour and efficiency can drive economic progress and urban expansion, increasing the pressure on forests to convert land, accelerating the rate of deforestation and contributing to the degradation of environmental quality. López (1994), points out that as incomes rise, deforestation decreases as the implications of forest resources on agricultural production are internalized. It is therefore assumed that, as incomes rise, the rate of deforestation decreases, encouraging people to improve their forest reserves and environmental quality. Corroborating this notion by invoking the concept of forest transition, Perz (2007) asserts that the decline in forest cover is an inevitable repercussion of the development trajectory of nations. In the early phases of development, increasing population and food needs exert significant pressure on forested areas due to agricultural expansion; subsequently, as nations progress, growing demand for forest-related products and amenities stimulates the reforestation process, driven by key political entities (Barbier et al., 2010; Yeo and Huang, 2013).

This study is relevant for several reasons. Firstly, the study addresses the crucial issue of environmental degradation, in particular deforestation, and its implications for environmental quality in Africa. Using deforestation as an indicator of environmental quality (Cropper and Griffiths, 1994), the study highlights the impact of demographic factors on the natural environment, underlining the interconnection between demographic trends and environmental sustainability. Secondly, the study adopts a unique perspective by examining the potential influence of the demographic dividend on environmental quality in Africa; to our knowledge, few studies have analyzed this issue in the existing literature (Yaziz et al., 2022). This approach enables us to understand how population dynamics, in particular the demographic dividend, can affect environmental quality in African countries. This is a new angle that contributes to understanding the complex relationship between demography and environmental issues. Finally, given the growing concern about environmental degradation and the need for sustainable development in Africa, the results of the study are directly relevant to policy-making.

Following this introduction, the rest of the paper is structured as follows. Section 2 briefly reviews the literature. Section 3 describes the methodological strategy. Section 4 presents some stylized facts. Section 5 presents and discusses the empirical results. Conclusions and policy implications are presented in section 6.

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2. Literature review

In this section, two important themes are addressed. First, the development of a theoretical fusion is explored, followed by a concise empirical assessment.

2.1. Theoretical synthesis

Examining the relationship between the demographic dividend and environmental quality is a well-established area of study, based on the Kuznets environmental curve (Clydesdale, 2018). The theoretical debate on the environmental Kuznets curve in relation to demographic pressure is complex and the subject of much discussion within the academic community. From this review, two groups of explanations emerge, among others a traditional explanation group and a modern explanation group.

2.1.1. Traditional explanations

Numerous studies have highlighted the complex nature of the relationship between the demographic dividend and environmental quality. Nevertheless, a significant proportion of these texts also recognize the presence of both pessimistic and optimistic tendencies. Malthus (1798) argues that population expansion puts pressure on arable land, forcing the use of land of diminishing fertility. The deterioration of the environment, in a global context, leads to a drop in marginal labor productivity and, consequently, slows population growth rates. Thünen (1826), in his land rent theory of deforestation, suggests that as populations grow and urbanize, the demand for agricultural land increases, leading to the conversion of forests into agricultural areas. Similarly, increases in labor force and productivity can stimulate economic development and urbanization, further intensifying the pressure on forests for land conversion, which in turn increases the rate of deforestation, contributing to the degradation of environmental quality. For Whitaker (1940), it is important to understand the interconnectedness of ecosystems and the need to adopt sustainable resource management practices. Demographic dynamics can play a role in both the destruction and conservation of natural resources: as populations grow and urbanize, the demand for resources such as wood, water and land increases, putting greater pressure on ecosystems. This can lead to deforestation, pollution, habitat destruction and other negative impacts on environmental quality.

Boserup (1965) discusses the relationship between demographic change and the intensification of agriculture, as well as deforestation, supporting land use and agricultural practices, thus promoting the degradation of environmental quality. Ehrlich (1968), in his book "The Population Bomb", points out that population growth exerts enormous pressure on natural resources, leading to degradation of environmental quality and resource depletion. The demand for agricultural land leads to widespread deforestation and habitat destruction, making it necessary to control population growth. Bilsborrow (1987) supports this view, emphasizing the impact of demographic trends on land use and agricultural productivity, as population growth and distribution influence development. These complex interactions between population dynamics, land use and agricultural productivity can contribute to deforestation as farmers expand into forested areas to meet growing food demand, resulting in degradation of environmental quality and even loss of biodiversity.

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2.1.2. A modern thesis

The link between the demographic dividend and environmental quality has undoubtedly been the subject of debate since the time of Malthus (1798). Since the 1990s, a contemporary explanatory group known as "active neutralism" has emerged from this debate. Many researchers are elucidating the link between population expansion and environmental quality. López (1994) provides a theoretical analysis of the "environmental Kuznet curve (ECK) for deforestation", indicating that as incomes increase, deforestation decreases when the impacts of forest resources on agricultural production are internalized. As a result, it is assumed that as incomes increase, the rate of deforestation decreases, thus encouraging people to improve their forest resources and the quality of the environment. Munasinghe (1999) proposes that a harmonious balance between the economy and the environment throughout the development phase would be optimal, leading to a mutually beneficial solution using Kuznet's environmental curve theory for deforestation. From this perspective, Culas (2007) points out that factors associated with agricultural productivity, population dynamics, economic factors and government strategies in each region are presumed to influence deforestation and, consequently, environmental well-being. Consequently, institutions that guarantee property rights and implement improved environmental strategies to steer the system towards sustainable progress can mitigate the tilt of the environmental Kuznet curve (ECK) between income and deforestation (Motel et al., 2009).

In a critical vein, Arrow et al (1995) argue that economic growth or income is not a panacea for environmental concerns; economic and environmental strategies are not interchangeable, let alone demographic dividend policies. Echoing this point of view, Bhattarai and Hammig (2001) stress that the irreversible consequences of deteriorating environmental quality, such as the loss of biodiversity due to deforestation, must be fully recognized; it is therefore imperative to acknowledge a critical threshold in the development process. In another extension, Mather (1992), with his theory of forest transition, argues that as countries, using population dynamics, develop economically, they move from deforestation to reforestation. This transition occurs when industrialization and urbanization lead to a reduced demand for agricultural land, and great importance is attached to environmental conservation. Reinforcing this view, Perz (2007) argues that the decline in forest cover is an inevitable effect of a country's development process. In the early stages of development, increasing population and food demand will exert significant pressure on forest land due to agricultural expansion, then, as countries develop, growing demand for forest products and services stimulates the reforestation process, and this under the impetus of political institutions that play an important role (Barbier et al., 2010; Yeo and Huang, 2013).

2.2 Empirical work

Several hypotheses have been put forward in the academic literature to elucidate the impacts of the demographic dividend on environmental quality (Mariani et al., 2019). First, a group of explanations on the positive effects of the demographic dividend on environmental quality (Washington and Kopnina, 2022). Zhang et al. (2018) on a study "*How does demographic structure affect environmental quality? Empirical evidence in China*" using a panel of 29 Chinese provinces over a period from 1995 - 2012, having resorted to the econometric estimation technique of the generalized method of moments (GMM), find that overall demographic structure improves environmental quality. Van Dao and Van (2020) carried

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out a study entitled "*The impact of population growth on the environment: A brief review*" covering the period 1990-2018. The study focused on Vietnam's two main cities, Hanoi and Ho Chi Minh City. The authors used the DPSIR model (Dynamics - Pressure - State - Impact - Response) and concluded that population dynamics, combined with cultural factors, had a positive impact on environmental quality in these two cities. Studying "*Economic impact analysis on environmental degradation in Indonesia*" over a period from 1965 to 2019, Yuswinarto and Gunanto (2021), using the dynamic time series method with autoregressive distribution lag (ARDL), find that population dynamics contribute to improvements in environmental quality.

Then, on the other hand, there's a group explaining the negative effects of the demographic dividend on environmental quality. Magnani and Tubb (2008) analyze "*the link between economic growth and environmental quality: what is the role of demographic change*?" on a panel of 30 member countries of the Organization for Economic Cooperation and Development (OECD), over the period 1970 - 2002. Using econometric estimation techniques for fixed and random effects, they found that demographic change can increase pollution emissions while having a negative impact on abatement expenditure. Studying "*Population and lifestyle change in China: implications for environmental quality*" over a period from 1978 - 2012 using the weighted semi-parametric least squares (WSLS) estimation technique, Apergis and Li (2016), find that demographic change and changes in consumption behavior have contributed significantly to the degradation of environmental quality over the periods under study. Dimnwobi et al. (2021) in their study "*Population dynamics and environmental quality in Africa*" on a sample of 5 African countries for the period 1990 - 2019, using Cross-sectionally Augmented Autoregressive Distributed Lag (CS-ARDL) econometric techniques, find that population dynamics further deepen environmental degradation.

Finally, a last group of explanations for the mixed effects of the demographic dividend on environmental quality. Cropper and Griffiths (1994), in a study of "*interactions between population growth and environmental quality*", based on a sample of 64 developing countries over the period 1961-1988, using the fixed-effects econometric estimation technique, found that macroeconomic relationships are often misinterpreted, indicating that rapid income growth alone is not sufficient to solve environmental problems, contrary to what is generally accepted, particularly in Latin American and African countries. The results highlight the implicit importance of a trade-off between per capita income, population density and land ownership rights that needs to be resolved. Rahman (2017) in investigating "*do population density, economic growth, energy consumption and exports have a negative impact on environmental quality in high-population Asian countries?* " on a sample of 11 countries for a period from 1960 - 2014, using econometric estimation techniques among others the Fully Modified Ordinary Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS) methods, they find that energy consumption, exports and population density have a negative impact on environmental quality in the long term. The study also identified a short-term, one-way relationship between energy consumption, gross domestic product (GDP), exports and CO2 emissions, and found bidirectional causality between GDP and population density. Long-term bidirectional causality was also observed among the variables considered. In their study "*Influence of population structure and industrial growth on environmental quality*", Khan et al. (2021) focus on the countries of the South Asian Association for Regional Cooperation (SAARC) during the period 1985-2016, using the "Stochastic Impact by Regression on

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Population, Affluence, and Technology (STIRPAT)" framework. They find that a negative linear coefficient is observed for industrial expansion. In contrast, the positive quadratic coefficient validates the presence of Kuznets' inverted U-shaped pattern in SAARC member countries. Similarly, factors such as working-age population (demographic composition), urbanization and trade are negative indicators of environmental quality.

Overall, the theories as discussed in the above development, observed in different regions, support both, that as societies go through demographic and economic transitions, and postulate a strong desire for a shift from deforestation to forest restoration, and thus ç better environmental quality, driven by economic changes, land policies and technological advantages (Xiong et al., 2021; Estoque et al., 2022). The demographic dividend could play a crucial role in this change and in promoting sustainable development by giving countries the opportunity to invest in environmental conservation (Oliveira, 2018). To our knowledge, few studies have analyzed this issue in the existing literature, which is why this study has the privilege of investigating the role that the demographic dividend can play in improving environmental quality in Africa.

3. Methodological strategy

To analyze the quantitative aspect of the relationship between the demographic dividend and environmental quality in Africa, this section first presents the theoretical and empirical model. Secondly, to describe the data and the estimation technique.

3.1. From theoretical to empirical model

Little research has empirically investigated the relationship between the demographic dividend and environmental quality in Africa (Nguea, 2023). The basic framework used is based on the Environmental Kuznet Curve (EKC) for the empirical estimation of this study. Although most previous studies relating to the relationship between demographic variables and the environment have been based on the IPAT model proposed by Ehrlich and Holdren (1971), which, in turn, has been criticized for its weaknesses in relation to the EKC framework (Hassan and Salim, 2015). Supported by the study of Liddle (2015) and, Yaziz et al. (2022) this study adopts the EKC model for its advantages of studying the impact of various factors in addition to IPAT. Thus, applying the multiple linear regression model Yaziz et al. (2022) specifies a model as follows:

$$CO_{2it} = f\left(GDP_{it}, GDP_{it}^2, EC_{it}\right) \qquad (1)$$

Where CO_2 is carbon dioxide emissions per capita, GDP is real gross domestic product per capita, GDP^2 is real gross domestic product per capita squared, and EC represents energy consumption per capita. The indices $i\ et\ t$ represent the country and time dimension within a panel framework. Studying the link between population ageing and CO2 emissions without neglecting the vitality of income and the energy aspect on environmental quality, after transformation Yaziz et al. (2022) propose a model specified in natural log-linear form by integrating other factors as follows as follows:

$$lnCO_{2it} = \alpha + \beta_1\, lnGDP_{it} + \beta_2\, lnGDP_{it}^2 + \beta_3\, lnELC_{it} + \beta_4\, lnPA_{it} + \varepsilon_{it} \qquad (2)$$

Where CO_{2it} represents emissions of CO_2 emissions per capita, GDP_{it} is GDP per capita, GDP_{it}^2 represents real gross domestic product per capita squared, ELC_{it} is electricity consumption per

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capita and PA_{it} is the share of the population aged 65 and over in the total population. α et β correspond respectively to the values of the constant and the elasticity. The indices i et t denote country and year respectively, and ε_{it} is the error term.

We take this linear equation from Yaziz et al. (2022) and integrate our analysis variables. Thus, we rewrite this equation and replace the dependent variable by the environmental quality here captured by a proxy, which is deforestation (Cropper and Griffiths, 1994). Also, the variable of interest becomes the demographic dividend. Thus equation (2) is specified as follows:

$$ln\text{QUALENV}_{it} = \alpha + \beta_1\, ln\text{DD}_{it} + \beta_2\, ln\text{GDP}_{it} + \beta_3\, ln\text{NGIE}_{it} + \beta_4\, ln\text{POP}_{it} + \beta_5\, \text{DEMOC}_{it} + \varepsilon_{it} \quad (3)$$

Where $ln\text{QUALENV}_{it}$ represents environmental quality, $ln\text{DD}_{it}$ the demographic dividend, $ln\text{GDP}_{it}$ GDP per capita taken as income, $ln\text{NGIE}_{it}$ energy consumption, $ln\text{POP}_{it}$ total population, DEMOC_{it} democracy and ε_{it} is the error term. The indices i and t denote country and year respectively, and α and β correspond to the values of the constant and elasticity respectively. The β_1 à β_5 are parameters to be estimated.

3.2. Data and estimation techniques.

Various variable definitions and data sources are presented in this section. The research was conducted on a panel of 44 African countries. The sample selected was dictated by the availability of data series for all variables. Annual data cover the period from 1975 to 2021. Table 1 presents information on descriptive statistics, elucidating the general characteristics of the variables used in the study. In other words, the table delineates the quantity of observations in addition to the range (i.e. minimum and maximum values) for each variable. It also displays standard deviations and mean values. Examination of Table 1 reveals that environmental quality in African countries is characterized by an average rate of 3.574%, with minimum and maximum values of 0.894% and 4.425% respectively. The data also show that the selected countries have significant demographic dividend rates, ranging from 3.699% to 4.815% on average. It should be noted that some indicators show variability, as indicated by the standard deviation values. The correlation between variables is shown in Table 2.

Table 1. Descriptive statistics

Variables	Comments	Average	Standard deviations	Minimum	Maximum
lnQUALENV	2608	3,574	0,712	0,894	4,425
lnDD	2728	4,468	0,177	3,699	4,815
lnDDAJUST	2666	4,511	0,152	3,765	4,872
lnGDP	2309	6,998	0,9	5,119	9,628
lnNGIE	1199	6,315	0,632	4,728	8,118
lnPOP	2718	15,845	1,256	11,334	19,169
DEMOC	2727	0,286	0,187	0,009	0,789
Ouvcom	2123	0,592	0,301	0,008	3,48
lnIDE	2019	3,414	0,375	-12,364	4,883

Source : Authors

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Table 2 shows that the demographic dividend is negatively correlated with environmental quality. The independent variables show a rather divided association with environmental quality: some are negatively correlated while others are positively related. In addition, we find evidence of multicollinearity between the selected independent variables. Variance Inflation Factor (VIF) values for all independent variables are presented in the appendix.

Table 2. Correlation matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) lnQUALENV	1.000					
(2) lnDD	-0.004	1,000				
(3) lnGDP	-0.159	-0,570	1,000			
(4) lnNGIE	-0.119	-0,460	0,705	1,000		
(5) lnPOP	-0.005	0,105	-0,316	-0,103	1,000	
(6) DEMOC	0.230	-0,341	0,174	0,086	-0,181	1,000

Source : Authors

Numerous previous studies have revealed that environmental quality is affected by several variables. In the context of this study, the following are the ones that caught our attention:

- Dependent variable:

Environmental quality (lnQUALENV): refers to the overall state of the environment, including air, water, soil and biodiversity quality, as well as the sustainability of natural resources (Mensah et al., 2021). There are several measures of environmental quality, including deforestation (Cropper and Griffiths, 1994), CO2 emissions (Avom et al., 2020), ecological footprint (Dimnwobi et al., 2021), ... all influenced by human activities. For Cropper and Griffiths (1994), considering deforestation as a proxy in the analysis of environmental quality is a better indicator reflecting a certain reality in developing countries, particularly those in Africa (Rudel, 2023). The World Bank's Development Indicators database has provided such data (WDI, 2023).

- Variable of interest:

The demographic dividend (lnDD): is a concept that describes a phase of economic expansion that can occur when a country's working-age population exceeds its dependent population of children and the elderly (Bloom and Williamson, 1998; United Nations, 2013). The demographic dividend can also influence environmental quality (Yaziz et al., 2022). In cases where a country experiences economic expansion and increased efficiency due to a larger working-age population, degrees of industrialization, urbanization and resource use may increase (Zhang et al., 2018; Asongu et al., 2020). Consequently, this can lead to environmental problems such as air and water contamination, deforestation, habitat loss and amplification of greenhouse gas emissions. These data come from the World Bank's Development Indicators database (WDI, 2023).

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- Control variables:

Gross domestic product, here taken as income (lnGDP): is an economic indicator frequently used to quantify the aggregate monetary value of goods and services generated within a country's borders over a given period, usually on an annual or quarterly basis (WDI, 2023). As a measure of a country's economic output and overall economic health, it does not directly take into account environmental quality or sustainability. Traditional GDP growth is generally achieved at the expense of environmental quality and resource depletion. So is participating in its improvement (Jain and Jain, 2016; Khan et al., 2021). These data come from the World Bank's Development Indicators database (WDI, 2023).

Energy consumption (lnNGIE): This is the equivalent in kilograms of oil of energy consumption per constant PPP GDP. Energy consumption corresponds to primary energy use before transformation into other end-use fuels, which is equal to domestic production plus imports and stock changes, minus exports and fuel supplied to ships and aircraft engaged in international transport (WDI, 2023). Apergis and Li (2016) argue that energy consumption influences environmental quality. These data come from the World Bank's database of development indicators (WDI, 2023).

Population (lnPOP): refers to the total population of a country, counting all residents regardless of their legal status or citizenship (WDI, 2023). Population size and growth can have a significant impact on environmental quality. As the population of a region increases, so does the demand for resources such as water, energy and land, leading to increased pressure on the environment (Baus, 2017; Dimnwobi et al., 2021; Udemba et al., 2024). These data come from the World Bank's Development Indicators database (WDI, 2023).

Democracy (DEMOC): represents a system of governance in which authority is vested in the people, whether through direct participation or through elected representatives. In a democratic framework, individuals have the privilege of participating in the formulation of choices that affect their lives. Farzin et al (2006) and, Akalin and Erdogan (2021) assert that a democratic system does or does not enable greater citizen participation and responsibility in decision-making processes that have an impact on the environment. These data come from the Variety Democracy (VDEM) database (Nord et al., 2024).

The model is estimated mainly using the Pooled Mean Group (PMG) method. The choice of this estimation technique is motivated by the advantages it offers from a practical point of view. On the one hand, the Pooled Mean Group (PMG) estimator enables efficient treatment of dynamic panels, particularly those for which the number of time observations T is as large as the number of individuals N (Pesaran et al., 1999). On the other hand, it offers the possibility of estimating a long-term relationship between different variables, without prior precautions concerning stationarity or even the existence of a cointegrating relationship between the latter. To this end, estimation is based on the assumption that the model constant, as well as the short-term coefficients and error variances, may differ between individuals, while the long-term coefficients are identical. Borrowing the notation of Pesaran et al. (1999), we set out the principle of the method formally below. Given a sample of N individuals observed over T periods, with $(N, T) \in N \; x \; N$. Consider the following ARDL model $(p;\ q_1; \ldots\ ;\ q_k)$ model:

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$$y_{it} = \sum_{j=1}^{p} \lambda_{ij}\, y_{i,t-j} + \sum_{j=0}^{q} \delta'_{ij}\, X_{i,t-j} + \mu_i + \varepsilon_{it} \qquad (1)$$

$i = 1, 2, \dots, N\ ;\ t = 1, 2, \dots, T$

Where X_{it} is a matrix of explanatory variables of format $(k\ x\ 1)$; μ_i represents individual fixed effects; the λ_{ij} are coefficients assigned to the lagged individual dependent variables $(y_{i,t-j})$and δ'_{ij} is a matrix of scalars of format $(k\ x\ 1)$.

Equation (1) can be reformulated to obtain an error-corrected representation expressed in the following equation:

$$\Delta y_{it} = \Phi_i y_{i,-1} + X_i \beta_i + \sum_{j=1}^{p-1} \lambda^*_{ij}\, \Delta y_{i,-j} + \sum_{j=0}^{q-1} \delta^*_{ij}\, \Delta X_{i,t-j} + \mu_i + \varepsilon_{it} \qquad (2)$$

By stacking all observations for each individual "i", equation (2) is equivalent to the following equation (3):

$$\Delta y_{it} = \Phi_i y_{i,-1} + X_i \beta_i + \sum_{j=1}^{p-1} \lambda^*_{ij}\, \Delta y_{i,-j} + \sum_{j=0}^{q-1} \Delta X_{i,t-j}\, \delta^*_{ij} + \mu_i \tau + \varepsilon_{it} \qquad (3)$$

Where $y_i = (y_i 1, y_i 2, \dots, y_i T)'$ is a format matrix $(T\ x\ 1), X_i = (X_i, \dots, X_i T)'$ a format matrix $(T\ x\ k), et\ \tau = (1, 1, \dots, 1)'$ is a format matrix $(T\ x\ k)$. The following assumptions underlie the model described in equation (3):

- Disturbances ε_{it} are independently and identically distributed white noise. They are also independent of the regressors X_{it}.

- Equation 3 is stable. This implies that we have $\Phi_i < 0$i.e. the roots of the operator polynomial $\sum_{j=1}^{p} \lambda_{ij}\, z^j$ operator polynomial lie outside the unit circle, indicating the existence of a long-term relationship between the level variables. This relationship is expressed by the following equation:

$$y_{it} = -(\beta'_i / \Phi_i) X_{it} + \eta_{it} \qquad (4)$$

Where η_{it} is a stationary process.

- Coefficients are homogeneous in the long term. In the short term, however, coefficients may differ between individuals. Formally, in the long term, we have :

$$\theta_i = \theta = -\beta_i / \Phi_i \qquad (5)$$

Under the three previous assumptions, equation (3) can still be written as follows:

$$\Delta y_i = \Phi_i \Gamma_i(\theta) + W_i K_i + \varepsilon_i \qquad (6)$$

Where $\Gamma_i(\theta) = y_{i,-1} - X_i \theta$ is the error-correction term,

$$W_i = \left(\Delta y_{i,-1}, \dots, \Delta y_{i,-p+1}, \Delta X_{i,-1}, \dots, \Delta X_{i,-q+1}, \tau\right)\ et\ K_i = (\lambda^*_{i1}, \dots, \lambda^*_{i,p-1}, \delta^{*'}_{i0}, \dots, \delta^{*'}_{i,q-1}, \mu_i)'$$

The model, and in particular the long-term coefficients, are estimated using the maximum likelihood method based on the following likelihood function (Pesaran et al., 1999):

$$e(\gamma) = -\frac{T}{2} \sum_{i=1}^{N} \ln 2\pi\sigma_i^2 - \frac{1}{2} \sum_{i=1}^{N} \frac{1}{\sigma_i^2} (\Delta y_i - \Phi_i \Gamma_i(\theta))'\, D_i (\Delta y_i - \Phi_i \Gamma_i(\theta)) \qquad (7)$$

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Where $D_i = I_T - W_i(W_i'W_i)^{-1}W_i^{-1}, \gamma = (\theta', \Phi', \sigma'), \Phi' = (\emptyset_1, \emptyset_2, \dots, \emptyset_N)', et\ \sigma' = (\sigma_1^2, \sigma_2^2, \dots, \sigma_N^2)$.

The estimators of the short-term and long-term coefficients, as well as the adjustment coefficients, are obtained by maximizing the log-likelihood function (7) with respect to γ. The maximization process is iterative, starting from an initial value $\hat{\theta}^{(0)}\ de\ \theta$ which is used to determine the estimators of fit coefficients and individual variances. These, in turn, are used to calculate a new value $\hat{\theta}^{(1)}$ and so on, until the maximum is reached.

The main reason for choosing this estimator lies in its compatibility with variables with different orders of integration, such as I (0), I (1), or a combination of these in the context of the variables under consideration. This confers a notable advantage on the autoregressive distributed lag (ARDL) approach, as it avoids the need and importance of performing unit root tests. In addition, it enables both short- and long-term effects to be estimated simultaneously within the analysis. The potential presence of endogeneity, particularly in the ARDL model using Pool Mean Group (PMG) estimators, guarantees the robustness of the coefficients by incorporating lags in the dependent and independent variables. Throughout this procedure, all estimators take long-term equilibrium into account, with the heterogeneity of the dynamic adjustment process assessed by maximum likelihood techniques. The ARDL model, implemented with an error correction mechanism, is a relatively recent technique for cointegration analysis; nevertheless, it is essential to ensure consistent and efficient parameter estimates to establish a lasting relationship. The preliminary tests used to select the PMG estimator are presented in the appendix.

4. Some stylized facts

Three stylized facts stand out from our observations of the demographic dividend and environmental quality in Africa.

4.1. Environmental quality declines in Africa

Over the past thirty years, African countries have faced a myriad of challenges, including population expansion, conflict, high national indebtedness, environmental disasters and epidemics, all of which have had a profound impact on the continent's population and diverse natural landscape (UNEP, 2023). In response to this challenging situation, many African countries are currently undertaking efforts, such as the New Partnership for Africa's Development (NEPAD), to address some of the fundamental factors contributing to this environmental deterioration. However, these efforts remain insufficient.

Capitalizing on the demographic dividend in Africa presents both advantages and challenges for improving environmental quality (Adedini et al., 2023). By addressing these challenges and capitalizing on the demographic dividend, Africa can move towards sustainable development and improved environmental quality (Yaziz et al., 2022). As shown in figure 1, countries such as Burundi, Côte d'Ivoire, Djibouti, Madagascar, Morocco, Nigeria, Rwanda, Somalia, South Africa, Togo and Uganda are the most affected by deforestation (WDI, 2023). According to Kossi et al. (2021) this can be justified by the fact that, in addition to the great need for land for agriculture, housing sprawl, socio-political conflicts, ... there is the existence of certain rites among others ritual fires and the cutting of wood in sacred groves (Havyarimana et al., 2018; Fandjinou et al., 2020; Suzzi-Simmons, 2023).

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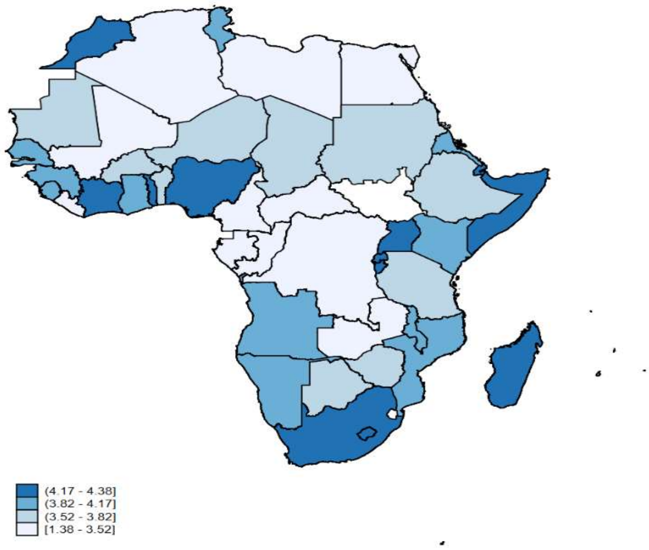
Figure 1. Representative mapping of environmental quality in Africa in 2020.



Source: Authors

4.2. The dynamics of the demographic dividend in Africa

Understanding population trends and forecasting demographic change are essential for formulating national development strategies and implementing the 2030 Agenda for Sustainable Development. The 2030 Agenda emphasizes the central role of people in sustainable development, reflecting the principles set out in the Programme of Action of the International Conference on Population and Development (ICPD) established in Cairo in 1994 (WPP, 2022). The unique shape of the age pyramid of the African population is influenced by several factors, as shown in figure 2.

First of all, the age distribution of Africa's population has undergone significant changes in recent decades (Pillay and Maharaj, 2012). This demographic shift makes Africa a demographic superpower, with a growing geopolitical and economic influence on the global landscape (Harpur and Ngalomba, 2016). In addition, sub-national variability in the age structure of the population reflects different levels of development, impacting economic prospects and health issues on the continent (Wilson, 2016; Pezzulo et al., 2017). Africa's relatively young demographic structure plays an important role in shaping its population pyramid (Mougeni et al., 2020). Secondly, Africa's population has been growing rapidly, with over a billion people in 2020, and a significant proportion of people are under 15. The number of people aged 60 and over is increasing, and projections indicate that by 2050, this age group will account for around 9% of the African population, up from 5% at present (Kaba, 2020). Finally, these factors collectively contribute to the distinct shape of the age pyramid observed in the African population, underlining the importance of understanding demographic dynamics for effective policy formulation and planning (Muza and Mangombe, 2019; Widayani et al., 2020).

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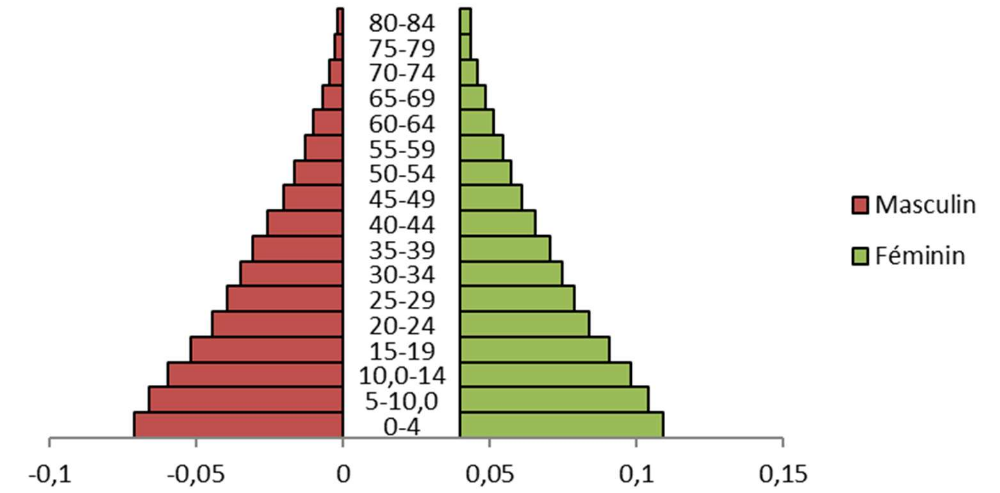
Figure 2: Age pyramid of the African population 2000 to 2021

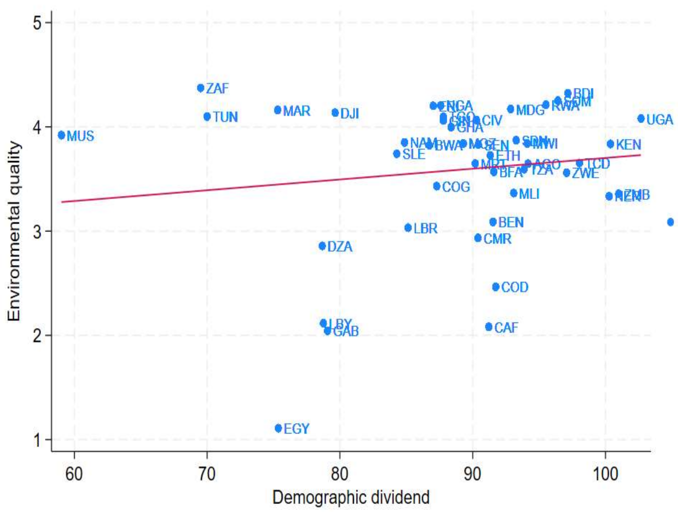


Source: Authors

4.3. The demographic dividend is positively correlated with environmental quality in Africa.

The demographic dividend refers to the potential for economic growth that can result from changes in the age structure of a population, typically due to declining fertility and mortality rates (Bloom and Williamson, 1998; United Nations, 2013). This demographic transition can lead to an increase in the working-age population relative to the dependent population, which can boost productivity and economic growth (Cowgill, 1963). As Figure 3 shows, the demographic dividend is positively correlated with deforestation and therefore environmental quality in Africa (WDI, 2023).

Figure 3: Correlation between the demographic dividend and environmental quality in Africa.



Source: Authors

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One of the ways in which the demographic dividend can have a positive correlation with environmental quality, particularly in terms of deforestation, is through changing consumption patterns. When countries benefit from the demographic dividend and their economies grow, individuals may have more disposable income to purchase goods and services (Pautrel, 2009). This increased consumption can stimulate demand for deforestation-related products such as timber, palm oil and beef. However, as countries progress through their demographic transition and become more economically developed, they often turn towards service industries and away from resource-intensive industries such as logging and agriculture. This structural transformation can lead to a reduction in deforestation rates, as countries move towards more sustainable economic activities. In addition, when countries experience economic growth thanks to the demographic dividend, they may invest more in conservation efforts and sustainable development practices (Mulugeta Woldegiorgis, 2023). These may include initiatives to protect forests, promote reforestation and implement policies to reduce deforestation rates.

5. Results and discussion

The basic results, followed by the robustness results, are presented in this section.

5.1. Basic earnings

Table 3 presents the results of the effects of the demographic dividend on environmental quality in Africa. Three versions of the Pooled Mean Group (PMG) estimator are used: the Pooled Mean Group (PMG, column 1), the Dynamic Fixed Effect (DFE, column 2) and the Mean Group (MG, column 3). The results show that the PMG estimator has the highest overall effect on environmental quality, with the DFE estimator having the second-highest effect. The MG estimator has the lowest effect. All models are stable in terms of model recall strength, which is significant and negative in the econometric form. The table shows two trends, a short-term relationship and a long-term relationship. We focus on the long-term relationship, which is the particularity of the PMG estimator.

As regards the long-term relationship, the PMG results show an overall positive relationship between the demographic dividend (lnDD), GDP/capita (lnGDP), energy consumption (lnNGIE), population (lnPOP), democracy (DEMOC) and deforestation (lnQUALENV) at different significances. Thus, a 1% increase in the demographic dividend, GDP/capita, energy consumption and democracy leads to an increase in deforestation in Africa of 0.367%; 0.090%; 0.174% and 1.542% respectively, thus contributing to the degradation of environmental quality. In addition, a 5% increase in population leads to a 0.098 unit increase in deforestation, further contributing to the degradation of environmental quality in Africa. It is important to emphasize that the demographic dividend, energy consumption and democracy may, in view of the results, constitute a threat to environmental quality in Africa. These results are in line with Pautrel (2009), who argues that when a state benefits from the demographic dividend and the economy develops, individuals may have more disposable income. This increases their consumption, and can stimulate demand for products linked to deforestation, such as palm oil, timber, beef and so on. And the malfunctioning of democracy can contribute to increased deforestation and thus to the degradation of environmental quality (Akalin and Erdogan, 2021).

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This result is similar when the DFE estimator is used (column 2). However, the coefficients of the variables demographic dividend, energy consumption and population are high. In the literature, population pressure and energy consumption are factors that destabilize environmental quality (Cropper and Griffiths, 1994;Muza and Mangombe, 2019; Widayani et al., 2020; Mulugeta Woldegiorgis, 2023). The difference between PMG and DFE can be explained. PMG is based on the assumption that coefficients are the same for different subsets of the population. DFE, on the other hand, makes no such assumption and allows coefficients to vary according to subset. This could explain why the demographic dividend coefficient was higher when using DFE. In fact, DFE allows coefficients to vary between subsets, taking into account different factors that may influence the results. It is therefore able to take into account demographic differences and other factors likely to influence results, whereas PMG does not. The DFE is therefore more flexible and able to capture the effect of different demographic groups with greater precision. This gives a more nuanced view of the effect of the demographic dividend on deforestation, and thus on environmental quality, than the PMG model.

Table 3: Impact of the demographic dividend on environmental quality in Africa.

	(1)	(2)	(3)
VARIABLES	PMG	DFE	MG
ec	**-0.051****	**-0.043*****	**-0.495*****
	(0.024)	**(0.009)**	**(0.067)**
	Short-term relationship		
D_lnDD	0.332	-0.015	1.080**
	(0.219)	(0.085)	(0.517)
D_lnGDP	-0.003	0.002	-0.006
	(0.030)	(0.014)	(0.029)
D_lnNGIE	-0.008	0.035**	-0.226
	(0.051)	(0.016)	(0.296)
D_lnPOP	-0.687	-0.289*	4.418
	(0.987)	(0.165)	(4.883)
D_DEMOC	-0.071	0.004	-0.240
	(0.124)	(0.018)	(0.194)
	Long-term relationship		
L2.lnDD	0.367***	0.784***	0.617
	(0.117)	(0.304)	(0.475)
L.lnGDP	0.090***	-0.057	-0.075
	(0.029)	(0.096)	(0.053)
L.lnNGIE	0.174***	0.380**	0.533
	(0.031)	(0.150)	(0.328)
L.lnPOP	0.098**	0.184**	0.178
	(0.042)	(0.094)	(0.131)
L.DEMOC	1.542***	0.195	-0.927
	(0.258)	(0.201)	(0.765)
Constant	-0.072	-0.206*	-3.764*
	(0.044)	(0.112)	(2.064)
Comments	1,083	1,083	1,083

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Countries	29	29	29

Robust standard deviations in parentheses: *** p<0.01, ** p<0.05, * p<0.1
Source : Authors

5.2. Robustness analysis

We have so far demonstrated that the demographic dividend has a positive impact on environmental quality in African countries. In addition, we carry out three robustness analyses to ensure the validity of these results, leading to an observation of the channels through which the demographic dividend affects environmental quality in Africa.

5.2.1. Robustness analysis by regional effect.

Table 4 presents the results of the effects of the demographic dividend on environmental quality by geographical region in Africa. Three versions of the Pooled Mean Group (PMG) estimator are used: Pooled Mean Group (PMG), Mean Group (MG) and Dynamic Fixed Effect (DFE). The results show that the PMG estimator has the highest overall effect on environmental quality, while the DFE estimator has the second-highest overall effect. And the MG estimator has the lowest overall effect. The various models are stable overall in terms of recall force, which is significant and negative in econometric form. Two trends are displayed, a short-term and a long-term relationship. We focus on the long-term relationship, which is the particularity of the PMG estimator.

Firstly, in the long-term relationship, the PMG results show a relationship between GDP per capita (lnGDP), population (lnPOP), democracy (DEMOC) and deforestation (lnQUALENV) in the Southern African region. A 10% increase in GDP per capita leads to a 0.063% increase in deforestation. A 10% decrease in population leads to a -0.155% reduction in deforestation. On the other hand, a 5-unit increase in democracy leads to a 0.204% increase in deforestation. These results are consistent with other studies (Cropper and Griffiths, 1994; Yuswinarto and Gunanto, 2021; Mulugeta Woldegiorgis, 2023). Countries that enjoy economic growth thanks to demographic dividends can invest more in conservation and sustainable development. In addition, the age structure of the population reflects different levels of development (Palo, 1994; Pezzulo et al., 2017). The DFE estimator also demonstrates a relationship between demographic dividends (lnDD), energy consumption (lnNGIE), population (lnPOP) and deforestation (lnQUALENV). A 5% increase in demographic dividends leads to a 0.443% increase in deforestation in Southern Africa. A 1% increase in population leads to a 0.219% increase in deforestation. On the other hand, a 10% reduction in energy consumption leads to a -0.199% reduction in deforestation. These results are consistent with other studies (Mills Busa, 2013; Gul et al., 2016; Oyetunji et al., 2020; Hamoda, 2020). Reduced energy consumption, due to population pressure, can have a significant impact on deforestation rates. Reduced energy consumption can lead to lower demand for wood products, easing pressure on forests (Klenk et al., 2012). In addition, a unified effort to reduce energy consumption can play a central role in reducing deforestation in this region.

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Table 4: Impact of the demographic dividend on environmental quality by African geographic region.

	Southern Africa			East Africa			West Africa			North Africa		
VARIABLES	PMG	MG	DFE	PMG	MG	DFE	PMG	MG	DFE	PMG	MG	DFE
ec	**-0.039**	**-0.366****	**-0.052*****	**-0.183***	**-0.546*****	**-0.090*****	**-0.280*****	**-0.583*****	**-0.036****	**-0.200*****	**-0.719*****	**-0.039**
	(0.056)	**(0.179)**	**(0.013)**	**(0.094)**	**(0.147)**	**(0.026)**	**(0.092)**	**(0.075)**	**(0.016)**	**(0.070)**	**(0.176)**	**(0.033)**
						Short-term relationship						
D_lnDD	-0.057	0.116	0.073	0.560	3.774*	0.240	1.195	1.031	0.267	0.230	0.231	0.086
	(0.054)	(0.081)	(0.054)	(0.403)	(2.076)	(0.402)	(1.137)	(0.772)	(0.187)	(0.269)	(0.305)	(0.237)
D_lnGDP	0.005	-0.002	-0.005	-0.204**	-0.127*	-0.157**	0.115*	0.099*	0.024	0.052	-0.020	-0.012
	(0.014)	(0.010)	(0.009)	(0.099)	(0.073)	(0.066)	(0.063)	(0.057)	(0.029)	(0.098)	(0.080)	(0.037)
D_lnNGIE	0.003	-0.005	-0.004	-0.155	-1.336	0.024	-0.011	0.027	0.005	0.118	0.226	0.137***
	(0.004)	(0.006)	(0.011)	(0.218)	(1.412)	(0.074)	(0.033)	(0.036)	(0.026)	(0.158)	(0.235)	(0.050)
D_lnPOP	-0.284*	0.011	-0.508***	-3.629	1.402	-1.744***	5.270	17.045	0.555	-2.627	-0.396	-1.242
	(0.158)	(0.232)	(0.120)	(3.053)	(2.409)	(0.498)	(6.139)	(20.415)	(0.348)	(2.148)	(2.531)	(0.999)
D_DEMOC	0.003	-0.016	0.003	-0.756	-1.314	0.096	0.005	0.057*	0.012	0.042	0.130**	-0.021
	(0.011)	(0.032)	(0.009)	(0.933)	(0.847)	(0.118)	(0.032)	(0.032)	(0.024)	(0.049)	(0.056)	(0.049)
						Long-term relationship						
L2.lnDD	-0.055	-0.206	0.443**	0.153	0.937	0.349	0.231***	1.917	2.028*	0.232**	0.285	1.312
	(0.049)	(0.139)	(0.215)	(0.210)	(1.429)	(0.623)	(0.054)	(1.516)	(1.105)	(0.096)	(0.289)	(1.332)
L.lnGDP	0.063*	-0.032	0.026	0.020	-0.094	0.674**	-0.092***	-0.070	-0.749	0.342***	-0.105	-0.702
	(0.037)	(0.023)	(0.072)	(0.034)	(0.227)	(0.272)	(0.016)	(0.056)	(0.468)	(0.061)	(0.130)	(0.942)
L.lnNGIE	0.014	-0.034	-0.199*	0.391***	1.747	-1.024**	0.076***	0.109	0.560	-0.088**	0.471	1.520
	(0.017)	(0.040)	(0.109)	(0.042)	(1.506)	(0.404)	(0.014)	(0.098)	(0.397)	(0.045)	(0.439)	(1.422)
L.lnPOP	-0.155*	0.019	0.219***	0.125***	0.494**	-0.214	0.190***	-0.115	0.081	-0.052	0.444	-0.100
	(0.090)	(0.047)	(0.068)	(0.039)	(0.247)	(0.247)	(0.013)	(0.422)	(0.214)	(0.072)	(0.292)	(0.483)
L.DEMOC	0.204**	-0.041	-0.053	0.144***	-4.454	-0.094	0.017	0.051	1.097*	-0.092*	0.132	-1.095
	(0.095)	(0.066)	(0.081)	(0.056)	(3.558)	(0.552)	(0.029)	(0.107)	(0.608)	(0.053)	(0.085)	(1.243)
Constant	0.211	1.555***	-0.008	-0.111	-12.166	0.722	-0.253	-1.849	-0.191	0.232**	-5.457	-0.163
	(0.316)	(0.584)	(0.115)	(0.148)	(8.265)	(0.645)	(0.282)	(1.634)	(0.230)	(0.112)	(4.456)	(0.330)
Comments	183	183	183	192	192	192	272	272	272	230	230	230
Countries	5	5	5	6	6	6	7	7	7	6	6	6

Robust standard deviations in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Sources : Authors

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Secondly, PMG results reveal a positive and significant relationship between energy consumption (lnNGIE), population (lnPOP), democracy (DEMOC) and deforestation (lnQUALENV) in the East African region. A 1% increase in energy consumption (lnNGIE), population (lnPOP) and democracy (DEMOC) leads to an increase in deforestation of 0.391%, 0.125% and 0.144% respectively. These results corroborate the work of Maji et al. (2017), Wehkamp et al. (2018), Raihan et al. (2022), Oko and Odey (2022), Rudel (2023) and Opoku and Sommer (2023). It should be noted that other factors can also be taken into account, although this is not exhaustive. In addition to foreign players such as importing countries and multinationals, various national entities, including local populations, government institutions and forestry companies, also contribute to the loss of forest cover. Political changes can increase pressure on forested areas, while economic factors such as rising agricultural costs and lack of non-agricultural employment opportunities can lead to deforestation. In addition, significant deforestation takes place in urban areas, as residents use firewood as a backup source of electricity during power outages, leading to deforestation (Cary and Bekun, 2021). These results vary when the DFE estimator is used. They show a varied overall relationship (positive and negative) between GDP per capita (lnGDP), energy consumption (lnNGIE) and deforestation (lnQUALENV). A 5% increase in GDP/capita leads to a 0.674% increase in deforestation. Conversely, a 5% reduction in energy consumption leads to a -1.024% reduction in deforestation, helping to improve environmental quality in this region of Africa. These results are in line with the work of Kathari et al. (2011), Kuhe et al. (2017), Leblois et al. (2017), Febriyanti et al. (2022) and Raihan et al. (2022). It should be noted that other factors can also be taken into account, although this is not exhaustive. The diversity of results between countries and zones can be explained by the dynamic impact of several countries within that specific region. Due to demographic pressure, countries are experiencing increasing rates of economic development and deforestation. Countries' consumption behavior may also be a contributing factor (Zhou et al., 2024).

Thirdly, PMG results reveal a significant relationship between demographic dividend (lnDD), GDP/capita (lnGDP), energy consumption (lnNGIE), population (lnPOP) and deforestation (lnQUALENV) in the West African region. A 1% increase in the demographic dividend, energy consumption (lnNGIE) and population (lnPOP) increases deforestation by 0.231%, 0.076% and 0.190% respectively. In contrast, a 1% reduction in GDP/capita (lnGDP) leads to a -0.092% reduction in deforestation. These results are supported by the work of Asongu and Jingwa (2012), Ahmed et al. (2015), Lawson and Late (2020), Oyetunji et al. (2020), Rashmi (2020), Raihan et al. (2022) and Ofozor et al. (2024). These results can be explained by demographic pressure, inadequate land tenure systems, poverty and political instability, which play a central role in the deforestation process in this region. The degradation of environmental quality resulting from deforestation poses a threat to the continent's limited water resources, exacerbates poverty in rural areas and amplifies the impacts of climate change. In addition, the growing demand for wood as an energy source puts further pressure on Africa's already dwindling forest reserves (Maina, 2018; Rudel, 2023). On the other hand, the use of the DFE estimator leads to results showing a positive relationship between the demographic dividend (lnDD), democracy (DEMOC) and deforestation (lnQUALENV). A 10% increase in the demographic dividend and democracy leads to an increase in deforestation of 2.028% and 1.097% respectively. These results are consistent with the work of Maina (2018) and Horning and Horning (2018), who indicate that improving the quality of democratic processes can

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reduce deforestation levels. However, failing political institutions in democratic systems can lead to challenges in resource allocation, increasing deforestation rates. Divergences in the governance frameworks present in different democratic configurations explain the contradictory conclusions of previous studies on the influence of democracy on deforestation. Democracies characterized by robust governance mechanisms are more effective at mitigating forest depletion than those with less vigorous governance structures (Morjaria, 2013). Thus, the quality of democracy and governance plays a central role in determining the scale of deforestation in Africa (Fischer et al., 2021).

And fourthly, looking at the long-term relationship in the North African region, PMG's results reveal a globally varied and significant relationship between the demographic dividend (lnDD), GDP/capita (lnGDP), energy consumption (lnNGIE), democracy (DEMOC) and deforestation (lnQUALENV). Thus, a 5% increase in the demographic dividend leads to a 0.232% increase in deforestation, encouraging the degradation of environmental quality in this region. Furthermore, a 1% increase in GDP/capita supports a 0.342% increase in deforestation, leading to a deterioration in environmental quality in this region. In contrast, a 5% reduction in energy consumption supports a -0.088% decrease in deforestation, leading to an improvement in environmental quality in this region of Africa. Furthermore, a 10% reduction in democracy leads to a -0.092% reduction in deforestation, reinforcing the improvement in environmental quality in this African region. These results corroborate the work of Galinato and Galinato (2009), Morjaria (2013), Asongu et al. (2020), Vasile (2020), Opoku and Sommer (2023), Ofozor et al. (2024). Without claiming to be exhaustive, these results can be justified by the fact that population growth, combined with other factors, plays a central role in deforestation in this specific region. The degradation of environmental quality resulting from deforestation is a major threat. Repressive political conditions can create a "good business climate" for multinational capital, leading to an increase or decrease in deforestation rates (Hammouyat et al., 2022).

5.2.2. Robust analysis by changing the measure of the demographic dividend.

Table 5 presents the results of the effects of the demographic dividend on environmental quality in Africa, observing the effect of changing the measure of the demographic dividend. Three versions of the Pooled Mean Group (PMG) estimator are used: Pooled Mean Group (PMG), Mean Group (MG) and Dynamic Fixed Effect (DFE). In terms of results, the PMG estimator has the highest overall effect on environmental quality, while the DFE estimator has the second-highest overall effect. The MG estimator has the lowest overall effect. The various models are stable overall in terms of recall force, which is significant and negative from an econometric point of view. Two trends are observed, a short-term and a long-term relationship. We focus on the long-term relationship, which is the particularity of the PMG estimator. Looking at the long-term relationship, PMG's results reveal that the demographic dividend has a positive sign on deforestation, further exacerbating the degradation of environmental quality in Africa (Allen and Barnes, 1985). This result is similar when using the DFE estimator.

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Table 5: Impact of the demographic dividend on environmental quality in Africa.

VARIABLES	(1) PMG	(2) DFE	(3) MG
ec	-0.028***	-0.041***	-0.146**
	(0.009)	(0.009)	(0.064)
	Short-term relationship		
D_lnDDAJUST	0.145*	-0.004	0.377
	(0.081)	(0.035)	(0.260)
D_lnGDP	-0.004	0.002	0.003
	(0.029)	(0.014)	(0.040)
D_lnNGIE	-0.022	0.034**	-0.161
	(0.057)	(0.016)	(0.200)
D_lnPOP	-1.418*	-0.160	30.437
	(0.860)	(0.158)	(30.575)
D_DEMOC	-0.101	0.001	-0.406
	(0.135)	(0.018)	(0.282)
	Long-term relationship		
D_lnDDAJUST	0.495***	0.474*	-0.065
	(0.075)	(0.287)	(0.284)
L.lnGDP	0.216***	-0.103	-0.158
	(0.031)	(0.103)	(0.135)
L.lnNGIE	-0.097*	0.308**	0.911
	(0.057)	(0.152)	(0.733)
L.lnPOP	0.282***	0.125	0.289
	(0.040)	(0.093)	(0.277)
L.DEMOC	0.677***	0.124	-0.448
	(0.107)	(0.210)	(0.386)
Constant	-0.099*	-0.070	-2.099
	(0.056)	(0.095)	(3.043)
Comments	1,083	1,083	1,083
Countries	29	29	29

Robust standard deviations in parentheses: *** p<0.01, ** p<0.05, * p<0.1
Source : Authors

5.2.3. Change in estimation technique

Table 6 presents the results of the impact of the demographic dividend on environmental quality in Africa, using a new estimation method. After accounting for time-varying individual effects using the PMG, DFE and MG estimators, we used the random fixed-effect estimator (Mundlak, 1961; Balestra and Nerlove, 1966), which has the advantage of correcting for any bias resulting from autocorrelation between individual effects and explanatory variables in the sample. The fixed-effects estimator is preferred to the Hausman test. The table reveals that the demographic dividend, at the individual level, encourages deforestation, thus contributing to further degradation of environmental quality in Africa.

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Table 6: Impact of the demographic dividend on environmental quality in Africa

VARIABLES	(1) FE	(2) RE
L.lnDD	0.074**	0.074**
	(0.032)	(0.032)
L.lnGDP	0.001	0.001
	(0.013)	(0.013)
L.lnNGIE	0.010	0.010
	(0.017)	(0.017)
L.lnPOP	0.127***	0.127***
	(0.012)	(0.012)
L.DEMOC	0.079***	0.079***
	(0.027)	(0.027)
Constant	1.018***	1.090***
	(0.346)	(0.351)
Comments	1,112	1,112
R-squared	0.207	
Countries	29	29
Countries fixed effects	yes	no

Robust standard deviations in brackets, *** p<0.01, ** p<0.05, * p<0.1
Source : Authors

5.2.4. Potential channels through which the demographic dividend affects environmental quality in Africa.

Having established the link between the demographic dividend and environmental quality, a study was carried out into the specific impacts of the demographic dividend on the environment. Although not all pathways were covered, the focus was on several key routes supported by available data: trade openness (OUVCOM) and foreign direct investment (FDI). Initially, regression analyses were carried out individually, with each variable regressed against the demographic dividend. The results, detailed in columns 1 to 2 of Table 7, indicate the high significance of all coefficients associated with the demographic dividend, implying a significant correlation between the demographic dividend and the identified channels. Subsequently, a regression analysis was carried out with environmental quality as the dependent variable, incorporating both the demographic dividend and the above-mentioned channels, as indicated in column 4. Compared to the results in column 3, where only environmental quality was regressed against the demographic dividend, the coefficient related to the demographic dividend increased slightly, from -0.100 to -0.101. In addition, the coefficients linked to trade openness and foreign investment retained their importance. Considering all the results, it becomes clear that trade openness (OUVCOM) and foreign direct investment (FDI) are the main channels through which the demographic dividend influences environmental quality (Mills Busa, 2013).

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Table 7. Channel test

VARIABLES	(1) OUVCOM	(2) FDI	(3) lnQUALENV	(4) lnQUALENV
L.lnDD	-0.187***	-0.152**	-0.100***	-0.101***
	(0.027)	(0.072)	(0.018)	(0.019)
L.OUVCOM				0.073***
				(0.015)
L.FDI				0.013**
				(0.006)
Constant	1.426***	4.093***	4.022***	3.957***
	(0.122)	(0.320)	(0.079)	(0.089)
Comments	1,811	2,019	2,608	1,811
R-squared	0.022	0.002	0.012	0.039
Countries	42	44	44	42

Robust standard deviations in brackets, *** p<0.01, ** p<0.05, * p<0.1
Source : Author

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Conclusion

African countries have the potential to reap the rewards of a demographic dividend through targeted, effective and coordinated policies that respond to environmental circumstances. However, consideration of temporal coherences between demographic and forestry transitions for environmental quality is necessary for dynamic equilibrium in socio-ecological contexts facilitating positive outcomes (Franco-Henao et al., 2018; Chen et al., 2023).

This manuscript was formulated with the aim of studying the impacts of the demographic dividend on environmental conditions in Africa. To achieve this objective, a first step was to carry out a comprehensive review of the existing theoretical and empirical literature in order to identify the research problem. The review revealed that considerable attention had been paid to the demographic dividend by researchers, mainly focusing on economic aspects. Nevertheless, it is imperative to consider environmental factors when examining the demographic dividend. Consequently, particular emphasis has been placed on the environmental implications of the demographic dividend in the African context. This article is framed within demo-economic theory, incorporating concepts such as Kuznet's environmental curve and land rent for deforestation, as well as forest transition theory. Importantly, it emphasizes the interaction between the demographic dividend and environmental well-being. Empirical evidence, using pooled mean group estimators, fixed effects and random effects, was analyzed to assess the influence of the demographic dividend on environmental quality in a panel of 44 African countries from 1975 to 2021. The results indicate that the demographic dividend is exacerbating environmental degradation in Africa.

Nevertheless, to reap the potential benefits of the demographic dividend on environmental quality in Africa, it is essential to implement supportive policies and make strategic investments. Governments and relevant stakeholders are urged to prioritize the development of sustainable agricultural techniques to mitigate deforestation, soil degradation and water contamination, while simultaneously improving food security and rural livelihoods. Encouraging the adoption of green technologies and innovations through tax breaks and incentives can stimulate economic growth while mitigating environmental damage. In addition, strengthening education and innovation initiatives through tax support can foster economic development while reducing environmental impact. It is also essential to strengthen environmental education and awareness in order to cultivate a culture of sustainable living and environmental management among the population. Implementing economic incentives such as Payment for Ecosystem Services (PES) can encourage local communities and landowners to conserve forests and natural habitats. In addition, investment in renewable energy infrastructure is essential to reduce dependence on fossil fuels and facilitate the transition to cleaner energy sources.

This study is subject to several limitations that call for further research. Future empirical work should examine other aspects of the demographic dividend as well as alternative approaches, including country-specific microeconomic approaches. Furthermore, African countries have not been grouped according to income levels in this study, and therefore further research in this direction would have more practical and relevant policy implications.

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Appendices

	Unit root test by Madala and Wu (1999)						Pesaran unit root test (2007)					
	Level variables											
	Specification without trend			Specification with trend			Trendless specification			Specification with trend		
Variable	lags	chi_sq	p-value	lags	chi_sq	p-value	lags	Zt-bar	p-value	lags	Zt-bar	p-value
lnAgriland	0	59.971	0.404	0	95.579	0.001	0	3.563	1.000	0	2.665	0.996
lnAgriland	1	52.153	0.691	1	82.772	0.018	1	1.763	0.961	1	0.565	0.714
lnAgriland	2	41.462	0.950	2	77.821	0.042	2	1.685	0.954	2	2.275	0.989
Ratio_dep	0	61.010	0.368	0	114.658	0.000	0	1.397	0.919	0	4.534	1.000
Ratio_dep	1	548.551	0.000	1	587.169	0.000	1	-7.468	0.000	1	-5.612	0.000
Ratio_dep	2	70.890	0.119	2	89.025	0.005	2	2.016	0.978	2	5.789	1.000
lnGDP	0	55.960	0.552	0	62.104	0.332	0	-0.103	0.459	0	0.734	0.769
lnGDP	1	57.980	0.476	1	85.517	0.011	1	0.602	0.726	1	0.354	0.638
lnGDP	2	54.771	0.596	2	98.604	0.001	2	0.555	0.710	2	0.543	0.706
lnNGIE	0	64.197	0.268	0	52.940	0.663	0	0.994	0.840	0	1.681	0.954
lnNGIE	1	61.791	0.342	1	51.254	0.722	1	0.482	0.685	1	1.007	0.843
lnNGIE	2	59.089	0.436	2	43.103	0.928	2	1.263	0.897	2	1.883	0.970
lnPOP	0	893.416	0.000	0	78.750	0.036	0	-0.451	0.326	0	10.315	1.000
lnPOP	1	146.347	0.000	1	856.356	0.000	1	-2.071	0.019	1	-11.805	0.000
lnPOP	2	229.644	0.000	2	66.533	0.207	2	1.982	0.976	2	6.585	1.000
v2x_polyar~y	0	85.724	0.010	0	72.327	0.098	0	-2.447	0.007	0	-0.299	0.382
v2x_polyar~y	1	123.454	0.000	1	129.159	0.000	1	-2.760	0.003	1	-0.031	0.488
v2x_polyar~y	2	169.239	0.000	2	157.690	0.000	2	-1.024	0.153	2	0.998	0.841

Source : Authors

Country list

Algeria	Ethiopia	Niger
Angola	Gabon	Nigeria
Benin	Ghana	Rwanda
Botswana	Guinea	Senegal
Burkina Faso	Kenya	Sierra Leone
Burundi	Liberia	Somalia
Cameroon	Libya	South Africa
Central African Republic	Madagascar	Sudan
Chad	Malawi	Tanzania
Congo, Dem, Rep,	Mali	Togo
Congo, Rep,	Mauritania	Tunisia
Ivory Coast	Mauritius	Uganda
Djibouti	Morocco	Zambia
Egypt, Arab Rep,	Mozambique	Zimbabwe
Eritrea	Namibia	

Source : Authors

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Variable	Unit root test madala and wu (1999)						Pesaran unit root test (2007)					
	First difference variables						First difference variable					
	Specification without trend			Specification with trend			Specification sana trend			Specification with trend		
	lags	chi_sq	p-value	lags	chi_sq	p-value	lags	Zt-bar	p-value	lags	Zt-bar	p-value
D_lnAgriland	0	724.295	0.000	0	637.730	0.000	0	-15.434	0.000	0	-14.370	0.000
D_lnAgriland	1	354.397	0.000	1	293.784	0.000	1	-8.816	0.000	1	-7.404	0.000
D_lnAgriland	2	205.472	0.000	2	156.966	0.000	2	-4.108	0.000	2	-1.912	0.028
D_Ratio_dep	0	65.246	0.239	0	40.075	0.965	0	0.891	0.814	0	0.587	0.722
D_Ratio_dep	1	183.798	0.000	1	169.291	0.000	1	-5.144	0.000	1	-5.063	0.000
D_Ratio_dep	2	84.788	0.012	2	47.874	0.826	2	0.221	0.587	2	0.845	0.801
D_lnGDP	0	705.398	0.000	0	642.762	0.000	0	-16.962	0.000	0	-15.869	0.000
D_lnGDP	1	363.787	0.000	1	329.476	0.000	1	-10.529	0.000	1	-9.942	0.000
D_lnGDP	2	243.743	0.000	2	217.725	0.000	2	-5.102	0.000	2	-4.797	0.000
D_lnNGIE	0	890.960	0.000	0	816.941	0.000	0	-20.161	0.000	0	-19.500	0.000
D_lnNGIE	1	442.026	0.000	1	407.928	0.000	1	-12.478	0.000	1	-11.554	0.000
D_lnNGIE	2	234.693	0.000	2	215.258	0.000	2	-7.549	0.000	2	-6.785	0.000
D_lnPOP	0	62.640	0.315	0	40.596	0.960	0	3.622	1.000	0	5.801	1.000
D_lnPOP	1	544.446	0.000	1	742.293	0.000	1	-14.405	0.000	1	-14.115	0.000
D_lnPOP	2	57.421	0.497	2	42.602	0.935	2	0.505	0.693	2	0.033	0.513
D_v2x_poly~y	0	692.284	0.000	0	578.479	0.000	0	-18.392	0.000	0	-16.286	0.000
D_v2x_poly~y	1	499.176	0.000	1	405.955	0.000	1	-13.012	0.000	1	-11.562	0.000
D_v2x_poly~y	2	428.187	0.000	2	235.425	0.000	2	-8.094	0.000	2	-6.146	0.000

Source : Authors

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References

Adedini, S., Taiwo, O., Smile, O., Ajala, O., Ojuko-Aladejana, S., & Akeni, P. (2023). How can African countries address climate change problems and optimise demographic dividends for socioeconomic development?. The Journal of Population and Sustainability, 7(2), 15-30.

Ahmed, K., Shahbaz, M., Qasim, A., & Long, W. (2015). The linkages between deforestation, energy and growth for environmental degradation in Pakistan. Ecological Indicators, 49, 95-103.

Akalin, G., & Erdogan, S. (2021). Does democracy help reduce environmental degradation? Environmental Science and Pollution Research, 28(6), 7226-7235.

Allen, J. C., & Barnes, D. F. (1985). The causes of deforestation in developing countries, Annals of the Association of American Geographers, 75(2), 163-184.

Apergis, N., & Li, J. (2016). Population and lifestyle trend changes in China: implications for environmental quality. Applied Economics, 48(54), 5246-5256.

Arrow, K., Bolin, B., Costanza, R., Dasgupta, P. S., Folke, C., Holling, C. S., Jansson, B., Levin, S., Mäler, K., Perrings, C. & Pimentel, D. (1995), Economic growth, carrying capacity, and the environment, Science, 268(5210), 520-521.

Asongu, S. A., Agboola, M. O., Alola, A. A., & Bekun, F. V. (2020). The criticality of growth, urbanization, electricity and fossil fuel consumption to environment sustainability in Africa. Science of the Total Environment, 712, 136376.

Asongu, S. A., & Jingwa, B. A. (2012). Population growth and forest sustainability in Africa. International Journal of Green Economics, 6(2), 145-166.

Avom, D., Nkengfack, H., Fotio, H. K., & Totouom, A. (2020). ICT and environmental quality in Sub-Saharan Africa: Effects and transmission channels. Technological Forecasting and Social Change, 155, 120028.

Bakehe, N. P. (2020). The effect of democracy on environmental degradation: the case of deforestation in the Congo Basin. Développement durable et territoires. Economics, geography, politics, law, sociology, 11(3).

Barbier, E. B., Burgess, J. C., & Grainger, A. (2010), The forest transition: Towards a more comprehensive theoretical framework, Land Use Policy, 27(2), 98-107.

Baus, D. (2017). Overpopulation and the Impact on the Environment. CUNY Academic Works. https://academicworks.cuny.edu/gc_etds/1906

Bhattarai, M., & Hammig, M. (2001), Institutions and the Environmental Kuznets Curve for deforestation: A crosscountry analysis for Latin America, Africa and Asia, World Development, 29(6), 995-1010.

Bilsborrow, R. E. (1987). Population pressures and agricultural development in developing countries: A conceptual framework and recent evidence. World development, 15(2), 183-203.

*Corresponding author.
*Presenting author.

Boserup, E. (1965). The conditions of agricultural growth: The economics of agrarian change under population pressure. Routledge.

Carr, D. L., Suter, L., & Barbieri, A. (2005). Population dynamics and tropical deforestation: state of the debate and conceptual challenges. Population and environment, 27, 89-113.

Cary, M., & Bekun, F. V. (2021). Democracy and deforestation: The role of spillover effects. Forest policy and economics, 125, 102398.

Chaurasia, A. R., & Chaurasia, A. R. (2020). Population effects of the environment. Population and Sustainable Development in India, 243-255.

Chen, X., Prata Menezes, N., Rusatira, J. C., Cardona, C., Odeku, M., Kioko, D., ... & Rimon, J. G. (2023). Demographic dividend-favorable policy environment in two pre-dividend African nations: review of national policies and prospects for policy amendments in Nigeria and Tanzania. BMC public health, 23(1), 1070.

Clydesdale, G. (2018). Poverty, sustainability and the demographic dividend. International Journal of Business and Emerging Markets, 10(1), 3-21.

Commoner, B. (1993). Population, development, and the environment: trends and key issues in the developed countries. International Journal of Health Services, 23(3), 519-539.

Cropper, M., & Griffiths, C. (1994). The interaction of population growth and environmental quality. The American Economic Review, 84(2), 250-254.

Culas, R. J. (2007) , Deforestation and the environmental Kuznets curve: An institutional perspective, Ecological Economics, 61(2- 3), 429-437.

Dimnwobi, S. K., Ekesiobi, C., Madichie, C. V., & Asongu, S. A. (2021). Population dynamics and environmental quality in Africa. Science of the Total Environment, 797, 149172.

Ehrlich, P. R. (1968). Population bomb. http://pinguet.free.fr/ehrlich68.pdf

Estoque, R. C., Dasgupta, R., Winkler, K., Avitabile, V., Johnson, B. A., Myint, S. W., ... & Lasco, R. D. (2022). Spatiotemporal pattern of global forest change over the past 60 years and the forest transition theory. Environmental Research Letters, 17(8), 084022.

Fandjinou, K., Zhang, K., Folega, F., Mukete, B., Yang, X., Wala, K., ... & Bohnett, E. (2020). Assessment of the Protected Areas Strategy in Togo under Sustainable Management: The Case Study of Oti-Keran, Togodo, and Abdoulaye Faunal Reserve. Open Journal of Ecology, 10(04), 141.

Farzin, Y. H., & Bond, C. A. (2006). Democracy and environmental quality. Journal of Development Economics, 81(1), 213-235.

Febriyanti, A. R., Ratnasari, R. T., & Wardhana, A. K. (2022). The effect of economic growth, agricultural land, and trade openness moderated by population density on deforestation in OIC countries. Quantitative Economics and Management Studies, 3(2), 221-234.

Fischer, R., Cordero, F. T., Luna, T. O., Velasco, R. F., DeDecker, M., Torres, B., ... & Günter, S. (2021). Interplay of governance elements and their effects on deforestation in tropical landscapes: Quantitative insights from Ecuador. World Development, 148, 105665.

*Corresponding author.
*Presenting author.

Franco-Henao, L., Rodriguez-Sumaza, C., Borondo-Arribas, C., & Muzigirwa-Muke, E. (2018). The demographic transition in the Democratic Republic of Congo: facts and challenges to reach a demographic dividend. African Population Studies, 32(2).

Galinato, G. I., & Galinato, S. P. (2009). Governance and deforestation due to agricultural land expansion (No. 2009-21).

Gul, S., Khan, M. A., & Khair, S. M. (2016). Population increase: A major cause of deforestation in district Ziarat. Journal of Applied and Emerging Sciences, 5(2), pp124-132.

Hammouyat, A., Ichen, A., Elmalki, M., & Chahhou, D. (2022). The degradation of forest areas in Morocco: Case of Benslimane province. Biosystems Diversity, 30(4), 388-396.

Hamoda, M. F. (2020). Role of Green Buildings in Reduction of Energy Consumption. In Gulf Conference on Sustainable Built Environment (pp. 439-451). Springer International Publishing.

Harpur, P., & Ngalomba, S. (2016). 'Long Lives Aren't Necessarily Happy Ones in Africa, Particularly for Women'. Particularly for Women'(October 12, 2016).

Havyarimana, F., Bamba, I., Barima, Y. S. S., Masharabu, T., Nduwarugira, D., Bigendako, M. J., ... & Bogaert, J. (2018). The contribution of IDP camps to landscape dynamics in southern and southeastern Burundi. Tropicultura, 36(2).

Horning, N. R., & Horning, N. R. (2018). Why deforestation persists in Africa: actors, interests, and interest alignment. The Politics of Deforestation in Africa: Madagascar, Tanzania, and Uganda, 1-41.

Iheonu, C. O., Muoneke, O. B., & Agbutun, S. A. (2023). Investigating the democracy and environmental sustainability nexus in 52 African countries: Evidence from two-stage least squares and quantile regression. Social Science Quarterly, 104(5), 1006-1019.

Jain, P., & Jain, P. (2016). Population and development: impacts on environmental performance. Chinese Journal of Population Resources and Environment, 14(3), 208-214.

Kaba, A. J. (2020). Explaining Africa's rapid population growth, 1950 to 2020: Trends, factors, implications, and recommendations. Sociology mind, 10(4), 226-268.

Kathari, V. P., Patil, B. G., & Das, S. (2011). An energy efficient re-reeling process for silk reeling industry to reduce deforestation.

Khan, A., Sicen, L., Khan, B., & Salman, N. (2021). On the influence of demographic structure and industrial growth on environmental quality. Journal of Environmental Management, 288, 112453.

Klenk, N. L., Mabee, W., Gong, Y., & Bull, G. Q. (2012). Deforestation, forest management and governance. eLS.

Kossi, A., Mazalo, K. P., Novinyo, S. K., & Kouami, K. (2021). Impacts of traditional practices on biodiversity and structural characteristics of sacred groves in northern Togo, West Africa. Acta Oecologica, 110, 103680.

*Corresponding author.
*Presenting author.

Koutika, L. S., Matondo, R., Mabiala-Ngoma, A., Tchichelle, V. S., Toto, M., Madzoumbou, J. C., ... & Nzila, J. D. D. (2022). Sustaining Forest Plantations for the United Nations' 2030 Agenda for Sustainable Development. Sustainability, 14(21), 14624.

Kuhe, A., Bisu, D. Y., & Iortyer, H. A. (2017). Optimization of cooking energy mix, an alternative strategy to reduce deforestation: An example of households and restaurants in the Bauchi Metropolis, Nigeria. African Journal of Science, Technology, Innovation and Development, 9(2), 207-213.

Lawson, L., & Late, L. (2020). A simple Ricardo-Malthusian model of population, deforestation and biodiversity loss (No. 2020.08).

Leblois, A., Damette, O., & Wolfersberger, J. (2017). What has driven deforestation in developing countries since the 2000s? Evidence from new remote-sensing data. World Development, 92, 82-102.

Liddle, B. (2000). Population growth, age structure, and environmental impact. Population and Environment, 21(4), 385-411.

López, R. (1994), The environment as a factor of production: The effects of economic growth and trade liberalization, Journal of Environmental Economics and Management, 27(2), 163-184.

Magnani, E., & Tubb, A. (2008). The link between economic growth and environmental quality: what is role of demographic change? International journal of global environmental issues, 8(4), 365-391.

Maina, P. M. (2018). Impact of poor governance on deforestation in Africa. https://www.researchgate.net/profile/Paul-Maina-Phd/publication/361024143_Impact_of_Poor_Governance_on_Deforestation_in_Africa/links/629868f2416ec50bdb03fcd8/Impact-of-Poor-Governance-on-Deforestation-in-Africa.pdf

Maji, I. K., Abdul-Rahim, A. S., Ndawayo, A. B., Ofozor, C. A., Basiru, H. A., & Mubarak, S. M. B. (2017). The relationship between income, energy consumption, population and deforestation for environmental quality in Nigeria. International Journal of Green Economics, 11(3-4), 204-216.

Mariani, F., Pérez-Barahona, A., & Raffin, N. (2019). Population and the environment: the role of fertility, education and life expectancy (pp. 295-322). Springer International Publishing.

Mather, A. S. (1992), The forest transition, Area, 24(4), 367-379.

Mensah, I. A., Sun, M., Omari-Sasu, A. Y., Gao, C., Obobisa, E. S., & Osinubi, T. T. (2021). Potential economic indicators and environmental quality in African economies: new insight from cross-sectional autoregressive distributed lag approach. Environmental Science and Pollution Research, 28(40), 56865-56891.

Mills Busa, J. H. (2013). Deforestation beyond borders: Addressing the disparity between production and consumption of global resources. Conservation Letters, 6(3), 192-199.

*Corresponding author.
*Presenting author.

Morjaria, A. (2013). Is democracy detrimental for the environment in developing countries? evidence from Kenya. Evidence from Kenya (September 1, 2013). Global poverty research lab working paper, (17-101).

Motel, P. C., Pirard, R., & Combes, J.-L. (2009), A methodology to estimate impacts of domestic policies on deforestation: Compensated Successful Efforts for "avoided deforestation" (REDD), Ecological Economics, 68(3), 680-691.

Mougeni, F., Mangaboula, A., & Lell, B. (2020). The potential effect of the African population age structure on COVID-19 mortality. Medrxiv, 2020-05.

Mulugeta Woldegiorgis, M. (2023). Towards inclusive development by harnessing the demographic dividend? Empirics for Africa. Journal of Social and Economic Development, 1-23.

Munasinghe, M. (1999), Is environmental degradation an inevitable consequence of economic growth: tunneling through the environmental Kuznets curve, Ecological Economics, 29(1), 89-109.

Muza, C., & Mangombe, K. (2019). Population development in Africa with special regards to ageing. African Population Studies, 33(2).

M. Hashem Pesaran, Yongcheol Shin and Ron P. Smith (1999). Pooled Mean Group Estimation of Dynamic Heterogeneous Panels. Journal of the American Statistical Association, 94(446), 621-634. doi:10.2307/2670182

Nguea, S. M. (2023). Demographic dividend and environmental sustainability: The mediating effects of economic growth, ICT, foreign direct investment, and urbanization. Next Sustainability, 2, 100005.

Nica, M., Petre, I. L., & Caraman, C. (2019). Influence of Population Growth on the Environment. Ovidius University Annals, Economic Sciences Series, 19(1), 260-265.

Nord, M., Lundstedt, M., Angiolillo, F., Borella, C., Gastaldi, L., Good God, A., ... & Lindberg, S. I. (2024). Democracy Winning and Losing at the Ballot: Democracy Report 2024. V-Dem Working Paper Forthcoming.

Ofozor, C. A., Abdul-Rahim, A. S., Chin, L., Bani, Y., & Sulaiman, C. (2024). Does deforestation endanger energy security? A panel GMM evidence from 47 sub-Saharan African countries. Environment, Development and Sustainability, 1-23.

Oko, P. E., & Odey, D. U. (2022). Impact of population growth on biodiversity loss in Boki agro-ecological rainforests, Cross River State, Nigeria. Global Journal of Pure and Applied Sciences, 28(1), 99-105.

Oliveira, C. E. D. (2018). Variations in forest cover and the international trade in agricultural commodities: an investigation in the light of Forest Transition Theory (Doctoral dissertation, University of São Paulo).

Olorunfemi, I. E., Olufayo, A. A., Fasinmirin, J. T., & Komolafe, A. A. (2022). Dynamics of land use land cover and its impact on carbon stocks in Sub-Saharan Africa: An overview. Environment, Development and Sustainability, 24(1), 40-76.

*Corresponding author.
*Presenting author.

Opoku, A., & Sommer, J. M. (2023). Can democracy reduce forest loss: a cross-national analysis. World Development Sustainability, 2, 100073.

Oyetunji, P. O., Ibitoye, O. S., Akinyemi, G. O., Fadele, O. A., & Oyediji, O. T. (2020). The effects of population growth on deforestation in Nigeria: 1991-2016. Journal of Applied Sciences and Environmental Management, 24(8), 1329-1334.

Palo, M. (1994). Population and deforestation. The Causes of Tropical Deforestation: The Economic and Statistical Analysis of Factors Giving Rise to the Loss of the Tropical Forests, 42.

Pautrel, X. (2009). Macroeconomic implications of demography for the environment: a life-cycle perspective. FEEM Working Paper. https://www.econstor.eu/bitstream/10419/53275/1/644834633.pdf

Perz, S. G. (2007), Grand theory and context-specificity in the study of forest dynamics: Forest transition theory and other directions, The Professional Geographer, 59(1), 105-114.

Pezzulo, C., Hornby, G. M., Sorichetta, A., Gaughan, A. E., Linard, C., Bird, T. J., ... & Tatem, A. J. (2017). Sub-national mapping of population pyramids and dependency ratios in Africa and Asia. Scientific data, 4(1), 1-15.

Pillay, N. K., & Maharaj, P. (2012). Population ageing in Africa. In Aging and health in Africa (pp. 11-51). Boston, MA: Springer US.

Preston, S. H. (1996). The effect of population growth on environmental quality. Population Research and Policy Review, 15, 95-108.

Rahman, M. M. (2017). Do population density, economic growth, energy use and exports adversely affect environmental quality in Asian populous countries?". Renewable and Sustainable Energy Reviews, 77, 506-514.

Rahman, M. M., Saidi, K., & Ben Mbarek, M. (2017). The effects of population growth, environmental quality and trade openness on economic growth: a panel data application. Journal of Economic Studies, 44(3), 456-474.

Raihan, A., Begum, R. A., Nizam, M., Said, M., & Pereira, J. J. (2022). Dynamic impacts of energy use, agricultural land expansion, and deforestation on CO2 emissions in Malaysia. Environmental and Ecological Statistics, 29(3), 477-507.

Rashmi, Kadu (2020). A study on the deforestation and forest degradation on the population. Vol. 22 No. 1 (2020): Vol 22 No. 1 (2020) http://www.gujaratresearchsociety.in/index.php/JGRS/article/view/4545

Rudel, T. (2023). Population, development and tropical deforestation: a cross-national study. In The causes of tropical deforestation (pp. 96-105). Routledge.

Sacande, M., Guarnieri, L., Maniatis, D., Marchi, G., Martucci, A., Mollicone, D., ... & Sanchez Paus Diaz, A. (2022) . Africa Open Data for Environment, Agriculture and Land (DEAL) and Africa's Great Green Wall.

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*Presenting author.

Samways, D. (2022). Population and sustainability: Reviewing the relationship between population growth and environmental change. The Journal of Population and Sustainability, 6(1), 15-41.

Shapiro, D. (1995). Population growth, changing agricultural practices, and environmental degradation in Zaire. Population and Environment, 16(3), 221-236.

Shaw, R. P. (1989). Rapid population growth and environmental degradation: Ultimate versus proximate factors. Environmental Conservation, 16(3), 199-208.

Suzzi-Simmons, A. (2023). Status of deforestation of Madagascar. Global Ecology and Conservation, 42, e02389.

Udemba, E. N., Khan, N. U., & Shah, S. A. R. (2024). Demographic change effect on ecological footprint: A tripartite study of urbanization, aging population, and environmental mitigation technology. Journal of Cleaner Production, 437, 140406.

United Nations Department of Economic and Social Affairs, UNDESA, Population Division. (2022). World Population Prospects 2022: Summary of Results. 2022, UN DESA/POP/2022/TR/NO. 3.

Vasile, M. (2020). The rise and fall of a timber baron: Political forests and unruly coalitions in the Carpathian Mountains of Romania. Annals of the American Association of Geographers, 110(6), 1952-1968.

Van Dao, N., & Van, V. H. (2020). Population growth on the environment: A short review. PalArch's Journal of Archaeology of Egypt/Egyptology, 17(6), 8348-8363.

Thünen, J. V. (1826). The isolated state. Relation to agriculture and national economy.

Xiao, H., Liu, J., He, G., Zhang, X., Wang, H., Long, T., ... & Cao, Q. (2022). Data-driven forest cover change and its driving factors analysis in Africa. Frontiers in Environmental Science, 9, 780069.

Xiong, B., Chen, R., An, L., Zhang, Q., & Xia, Z. (2021). Telecoupling urbanization and mountain areas deforestation between 2000 and 2020: Evidence from Zhejiang Province, China. Land Degradation & Development, 32(16), 4727-4739.

Wafiq, A. N., & Suryanto, S. (2021). The Impact of Population Density and Economic Growth on Environmental Quality: Study in Indonesia. Jurnal Ekonomi & Studi Pembangunan, 22(2), 301-312.

Wang, J., & Dong, K. (2019). What drives environmental degradation? Evidence from 14 Sub-Saharan African countries. Science of the Total Environment, 656, 165-173.

Washington, H., & Kopnina, H. (2022). Discussing the Silence and Denial around Population Growth and Its Environmental Impact. How Do We Find Ways Forward? World, 3(4), 1009-1027.

Wehkamp, J., Koch, N., Lübbers, S., & Fuss, S. (2018). Governance and deforestation-a meta-analysis in economics. Ecological economics, 144, 214-227.

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*Presenting author.

Whitaker, J. R. (1940), World view of destruction and conservation of natural resources, Annals of the Association of American Geographers, 30(3), 143-162.

Widayani, H., Nuraini, N., & Triska, A. (2020). Pyramid population prediction using age structure model. CAUCHY, 6(2), 66.

Wilson, T. (2016). Visualising the demographic factors which shape population age structure. Demographic Research, 35, 867-890.

Yaziz, N. A. M. M., Azlina, A. A., Hussain, N. E., & Koris, R. (2022). The impact of population ageing on the environmental quality in late-demographic dividend countries. International Journal of Social Economics, 49(4), 581-598.

Yeo, I.-Y., & Huang, C. (2013), Revisiting the forest transition theory with historical records and geospatial data: A case study from Mississippi (USA), Land Use Policy, 32, 1-13.

Yuswinarto, R., & Gunanto, E. (2021). Analysis of economic on environmental degradation in indonesia. Buletin Studi Ekonomi, , 251-263. doi:10.24843/BSE.2021.v26.i02.p08

Zhang, Z., Hao, Y., Lu, Z. N., & Deng, Y. (2018). How does demographic structure affect environmental quality? Empirical evidence from China. Resources, Conservation and Recycling, 133, 242-249.

Zhou, Z., Sharif, A., Inglesi-Lotz, R., & Bashir, M. F. (2024). Analyzing the interplay between energy transition, resource consumption, deforestation, and environmental factors on agricultural productivity: Insights from APEC countries. Journal of Cleaner Production, 141408.

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